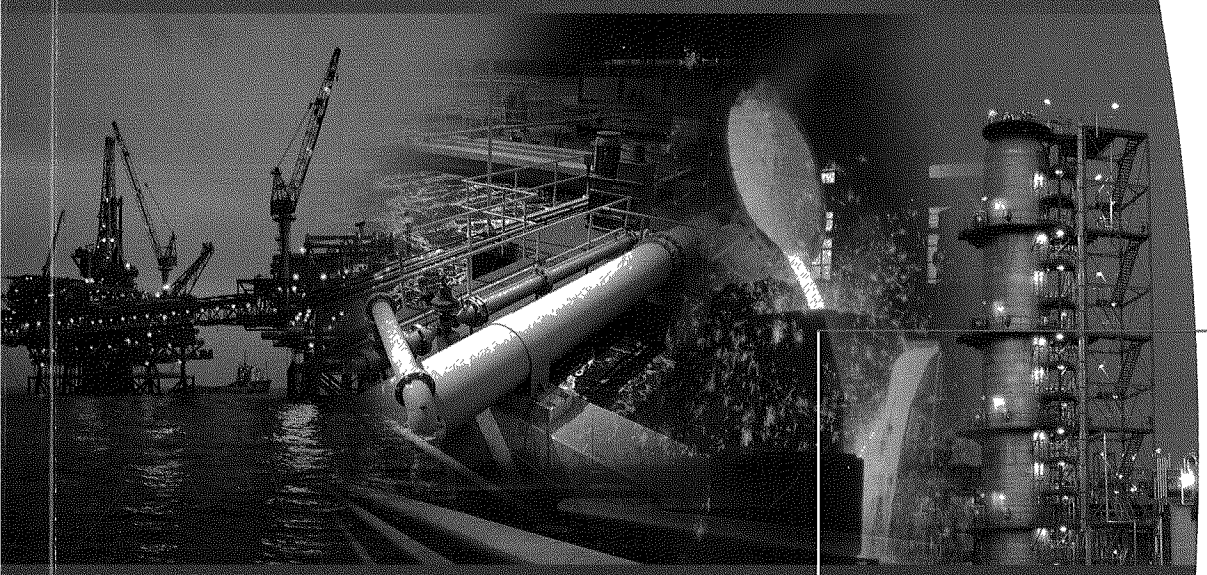
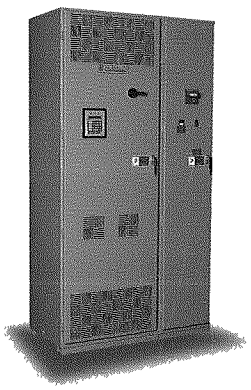
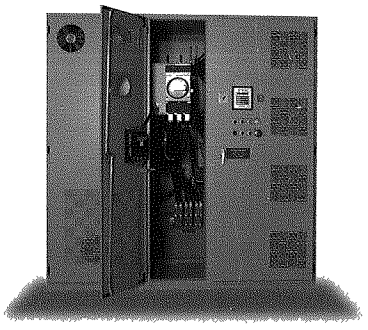
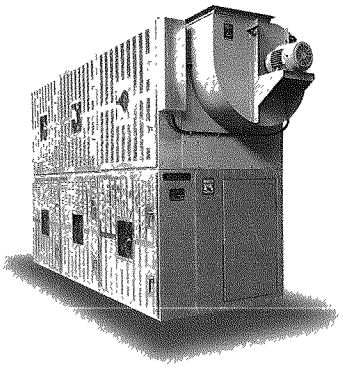


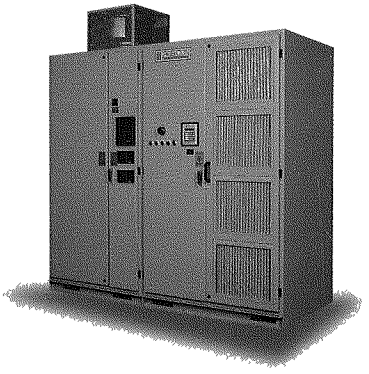


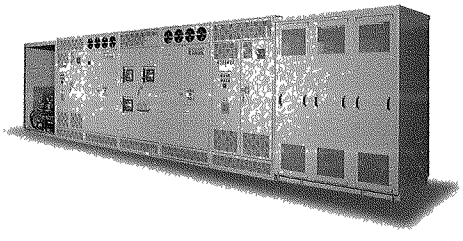


# Power

## Conversion Solutions







ROBICON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IP7_024754

In 1980, Robicon patented the first low harmonic power supply that provided high power factor over a wide range load without external filters.

Since then, our expertise in the design and manufacture of high current, high power, AC/DC specialty power supplies has led to the largest installed base and the most extensive product line of any power control manufacturer.

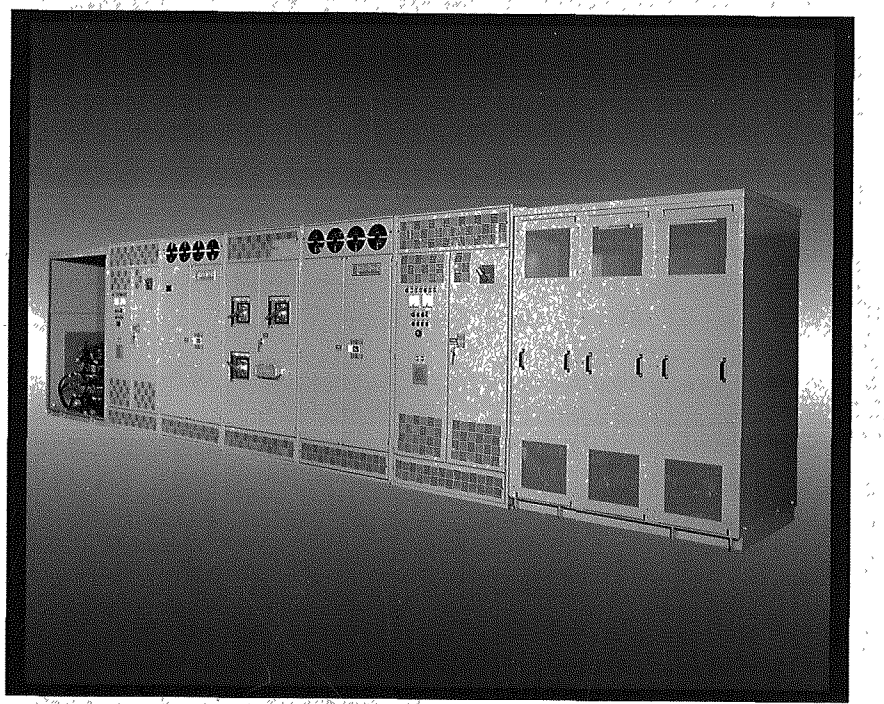
We tailor our products to meet specific customer needs, working in close partnership with our customers to configure custom system parameters.

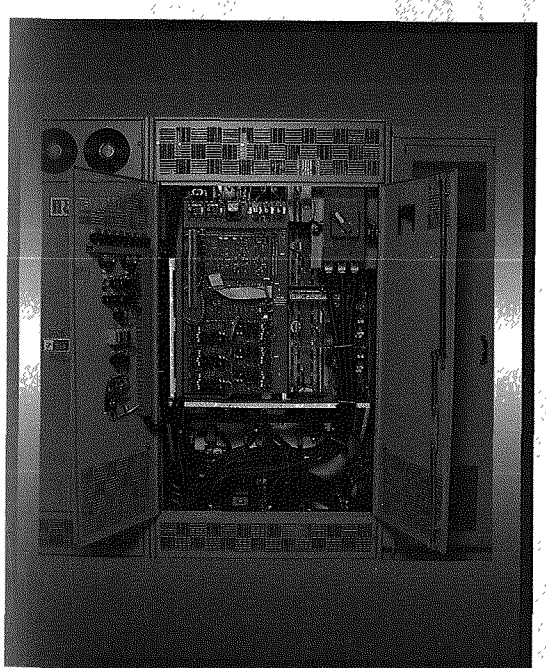

AC & DC Power Supplies

# Harmony Series

## AC & DC Power Supplies

0-6000 VOLTS
0-100,000 AMPS





The Harmony series is the only power supply designed to address all power quality issues. Modular packaging offers flexibility and power converters provide clean power input, high power factor, fast response and almost unlimited output capability.

# Harmony Power Supplies

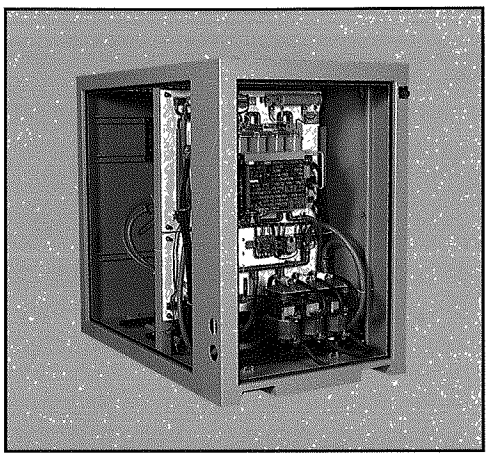
Since Robicon's inception, we have designed and manufactured equipment utilizing the latest available device technology from the semiconductor industry. From AC and DC thyristor power converter systems at 50 kW to 100 MW and 100 A to 100,000 A, to specialty-pulsed duty converters at 400 MW and 260,000 A, we have tailored equipment designs to meet specific customer requirements.

Robicon power supplies address the effective use of power to meet all or part of the industry and utility standards as the application and economics require. Our latest Harmony products have a great degree of modular construction and flexibility to address a wider range of customer applications.

## Typical Applications

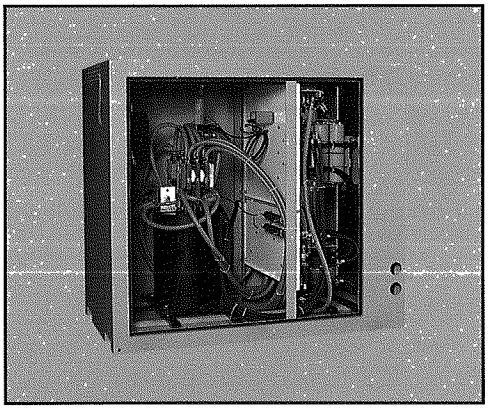
### AC Loads

- Glass melters
- Ozone generators
- Coating and film processes
- Polycrystal silicon processes
- Plasma processing
- High power, low harmonic 25/50 Hz power converters
- Furnace power supplies



### DC Loads

- Plasma torches
- Magnetic loads
- Electro-chemical processing/machining
- DC arc furnaces/smelting
- EW-SX processes
- Plasma coating & vapor deposition applications
- Single-crystal silicon growing processes
- Furnace power supplies (powdered metals/ceramics)



# Power Quality Input

## Clean Input Waveform

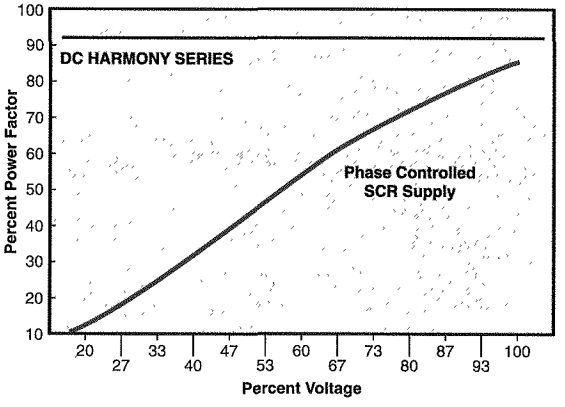
The Harmony series system meets the most stringent requirements of the IEEE 519 1992 standards for voltage and current harmonic distortion, even if the source capacity is no larger than the supply rating. The Harmony modules can also be supplied as separate units to answer various application, harmonic and power factor issues.

- Avoids costly harmonic filters and the associated losses and resonance problems
- Eliminates need for time consuming harmonic analysis
- Protects other on-line equipment from harmonic disturbance (computers, telephones, lighting ballast)
- Prevents interference with other power supplies
- Reduced plant power disturbances and flicker

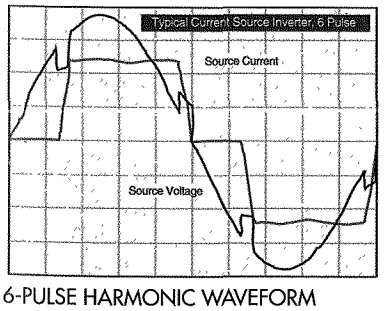
## High Power Factor

Exceeds .9 power factor throughout the operating range without external power factor correction capacitors

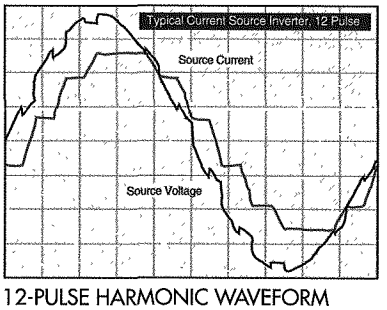
- Eliminates utility penalties for poor power factor and demand charges
- Avoids overloading feeder, breakers and transformers with reactive power
- Improves voltage regulation
- Ideal for variable voltage applications. A high and stable power factor is maintained throughout entire output voltage range



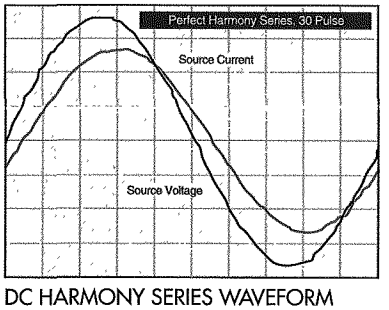

**Harmonic Comparison of Typical 1,000 kW SCR Power Supply vs. DC Harmony Series Operating from a 1,100 KVA, 5.75% Impedence Source.**




6-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 25% —*
*Total Harmonic Distortion (VOLTAGE) 10% —*



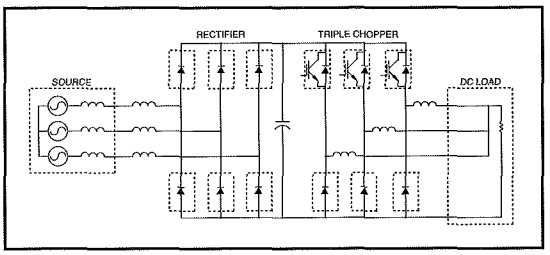

12-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 8.8% —*
*Total Harmonic Distortion (VOLTAGE) 3.9% —*




DC HARMONY SERIES WAVEFORM
*Total Harmonic Distortion (CURRENT) 0.8% —*
*Total Harmonic Distortion (VOLTAGE) 1.2% —*

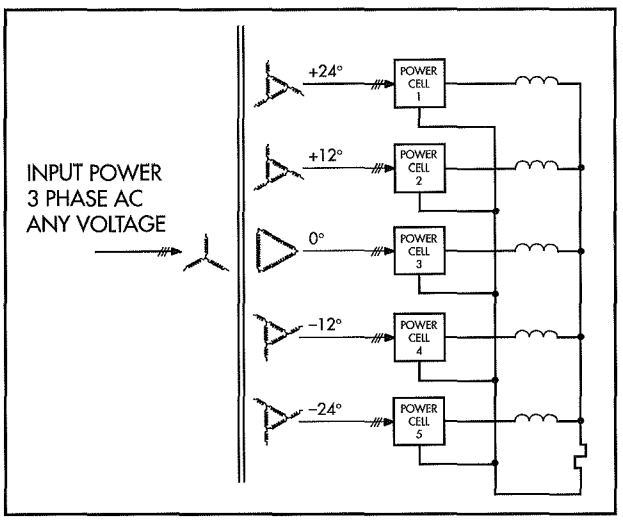
# Performance Features

The Harmony series power supply is a modular AC/DC design provided in a power module configuration based on voltage and/or current requirements. A typical DC Harmony power module for multi-zone furnace applications is shown.



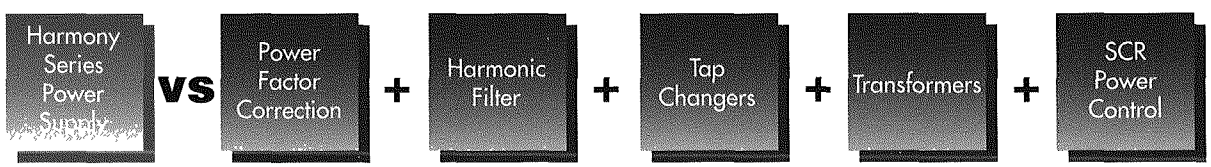

This design addresses a wide range of loads including Molybdenum Electrodes, Silicon Carbide Elements, Plasma Arcs, etc. To improve process performance, the units supply low ripple, fast response output to the load. This is accomplished while maintaining a power factor > 0.9, and a Total Harmonic Voltage Distortion ($THD_V$) level that is within the IEEE 519 1992 recommendations. Additional features include balanced AC input currents for single or unbalanced output loads, and the elimination of transformers and tap changers in many applications.

The Harmony power modules can be combined to accommodate the customer's power requirements and to provide optimum power quality. A typical Harmony system configuration is shown.




Harmony performance features in this configuration include Power Factor > 0.95, Efficiency > 95%, Low Harmonic Distortion ($THD_I$ < 5%, $THD_V$ < 3%), and Balanced Line Currents. This topology concept can be implemented with power modules, or it can be configured for AC single or three phase sine or square wave outputs. Voltage or current source techniques can also be utilized to fit the application. In all cases, fast response, low ripple and high quality output are provided to enhance the process.

When making the comparison between the Harmony power module design and the conventional Thyristor (SCR) approach, one should consider the Harmony advantages of higher power factor, lower harmonic distortion signature and smaller physical size. The basis of this comparison should be the system components necessary to achieve the same performance characteristics.




# Maximized Up Time

## Redundancy Option

In the unlikely event of a failure, the user may choose to operate the power supply at reduced capacity with one power section out. The redundancy option (n-1) permits back-up with a redundant power section to maintain full capacity operation.

## Short Circuit Immunity

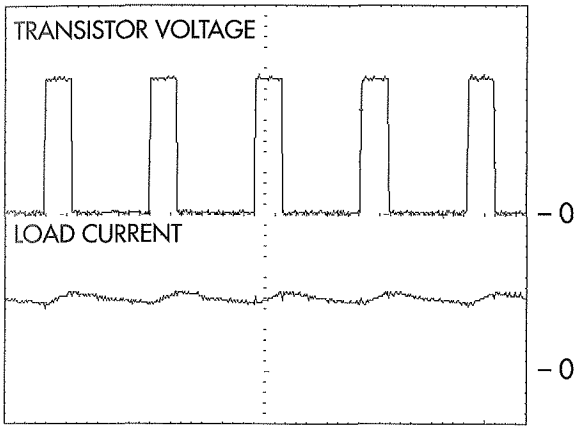
Rapid response of IGBT and/or Bipolar transistors chop load fault currents off in microseconds.

# Power Quality Output

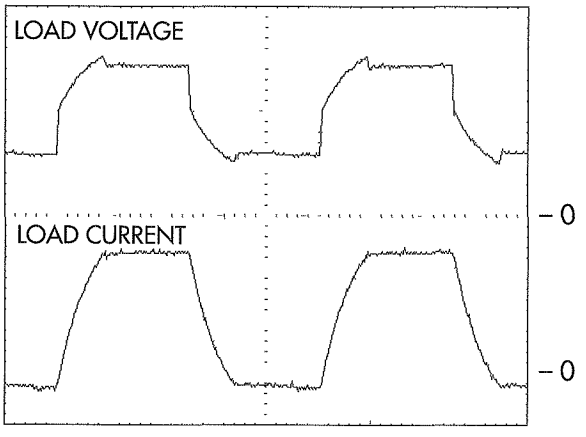
## Fast Response and High Quality Output

The Harmony series inherently provides fast response and high-quality output waveforms, resulting in:

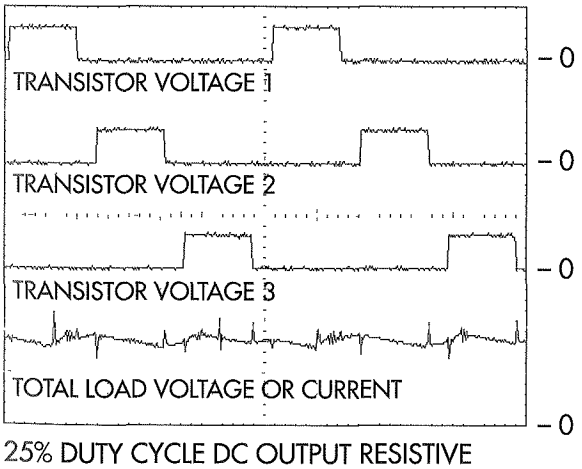
- Lower fault current
- Low ripple current
- Current/voltage/power regulation
- Current/voltage/power limit protection
- Potential process improvements



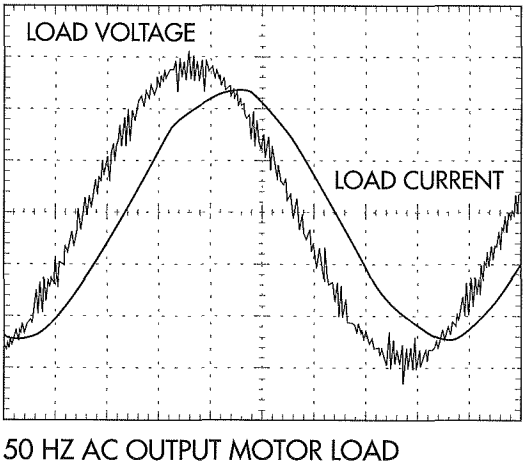

30% DC OUTPUT RESISTIVE LOAD




AC OUTPUT SQUARE WAVE RESISTIVE LOAD




25% DUTY CYCLE DC OUTPUT RESISTIVE

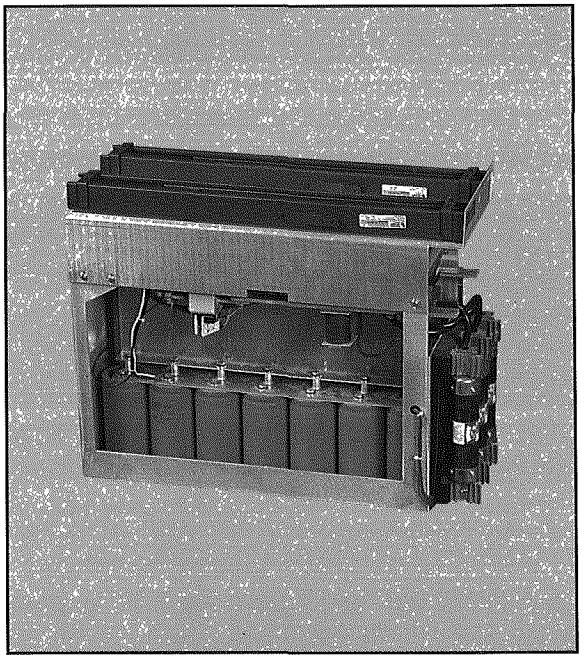



50 HZ AC OUTPUT MOTOR LOAD

# Features and Capabilities

## Modular Construction

The complete system can include, but is not limited to, an input switchgear section, a power transformer section, a power module converter section and a control section. This modular configuration allows equipment layout flexibility, ease in shipping and handling system components and maximized up-time by providing advantages in maintenance and serviceability.



## Input Switchgear Section

This section can include circuit breakers, contactors, lightning arrestors, protective relays, instrumentation, and/or any additional customer requirements.

## Power Transformer Section

The Harmony power transformer section can be provided with a dry type, oil filled or water cooled transformer for virtually any supply voltage. This Harmony-based transformer offers higher reliability than the equivalent transformer provided for a thyristor controlled system. For example, a typical 6-pulse thyristor power supply operating from a 60 Hz line has a harmonic spectrum with significant current harmonics to 2000 Hz. Each of these harmonic currents contributes as much to eddy current heating as the 60 Hz fundamental. IEEE, NEMA and UL all recognize this effect by establishing a "K" rating for transformers supplying non-sinusoidal loads. The "K" factor is the number by which the 60 Hz eddy current losses are multiplied to account for harmonic heating. The "K" rating for a phase controlled thyristor supply may exceed 15.

The near sinusoidal line current waveform of the Harmony series transformer greatly reduces parasitic heating from harmonic eddy currents and generally results in "K" factor of 4 to 6 for secondaries and only 2 for the primary. This removes many of the uncertainties in transformer design. The result is not only a higher level of reliability but improved efficiency as well — an important advantage in reducing process power costs.

## Power Converter Section

The Harmony power converter section comes equipped with power modules for high current applications, and output voltage requirements. The power modules are designed to partially rack-out of the enclosure for ease in servicing and maintenance, or fully for replacement. Modules are easily replaced.

## Cooling Options

The Harmony series is available with forced air or liquid cooling. The liquid cooled option can be provided with a self-contained, recirculating closed loop system, with either liquid-to-liquid or air-to-liquid heat exchangers. Redundant systems can be provided where necessary.

# Control Interface Features

The standard customer interface for control and metering consists of analog 4-20 mA or 0-10 V input and output signal levels. The on/off, protection and annunciation signals are derived via standard relay ladder logic in conjunction with control switches and door mounted oil-tight push buttons and lights.

### Custom Control Options Include:

- Industrial Programmable Logic Controller for I/O interface, control, diagnostics and communications.
- The power module design is available with an embedded micro/Programmable Logic Controller user interface featuring:
  - A. Keypad/Display Module for precise parameter setting and adjustments. The digital display is easy to read and program. Display screens for volts, amps, kW, elapsed time, etc. are readily keypad accessible.
  - B. Advanced Diagnostic programs provide continual, comprehensive monitoring of the supply functions. System fault displays provide easy to follow and extensive troubleshooting data.
  - C. Report printer output available.
  - D. Digital/Analog I/0 expansion modules available.

# Service Capabilities

### Sales and Application Engineers

Robicon has been manufacturing power converters for more than 30 years. Our engineers have many years of application specific experience in a wide variety of industrial applications and are strategically located at headquarters and regional offices. Assistance is also available through our network of manufacturer's representatives. Our representatives are the first step in developing a system solution that saves time and money.

### Technical Support Center

Associates at our 24-hour help line (724-339-9501) provide immediate telephone assistance for customers needing help with troubleshooting, programming, installation or start-up of Robicon systems. Our contact management computer system enables our associates to assure continuity of your dialogue and provide fast and accurate solutions.

### Field Service Representatives

Field service representatives provide 24-hour emergency response around the world from 50 international locations in addition to Robicon's factory. Our field service representatives are specifically trained to handle every phase of installation, start-up, maintenance and troubleshooting of Robicon systems and to take full advantage of Robicon's extensive technical and operational resources.

### Commitment Management

Robicon's process-based order fulfillment places sales and manufacturing engineers on the same team, ensuring all aspects of our commitment and diligent follow-through on your order. Dedicated associates are assigned to provide information and services regarding order status, prices, delivery and parts.

## Warranty

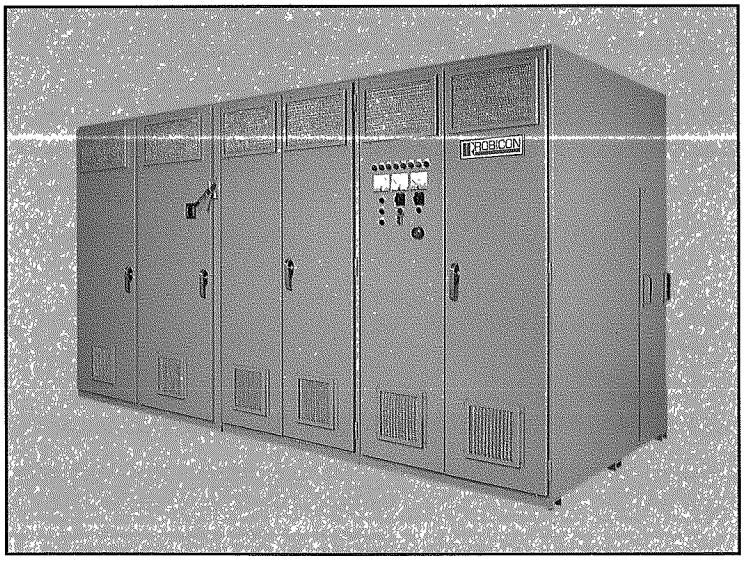
Unlike many power supply manufacturers, Robicon's warranty covers all on-site and in-house repairs, labor and materials.

## Technical Training

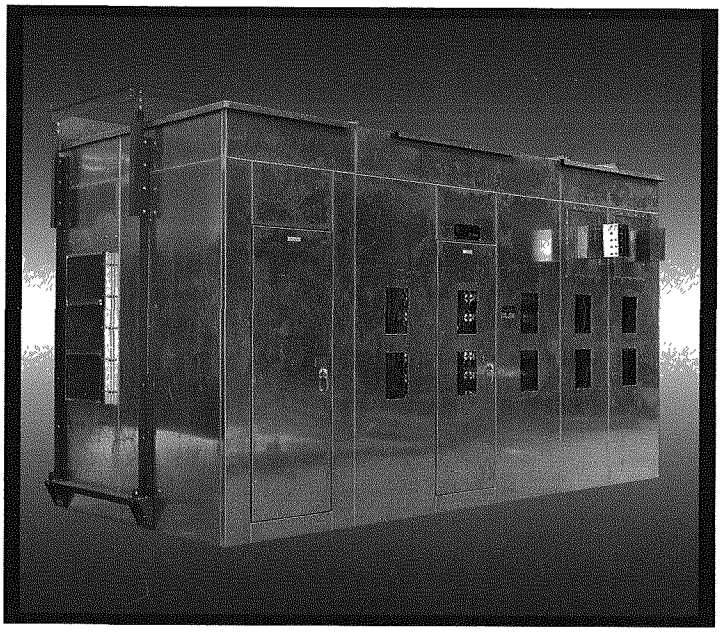
Our User Training Programs teach customers how to operate and maintain Robicon systems. These programs are conducted at customer sites and at Robicon's factory training center. Classes cover every system configuration with basic and advanced courses for design, operation and maintenance personnel.

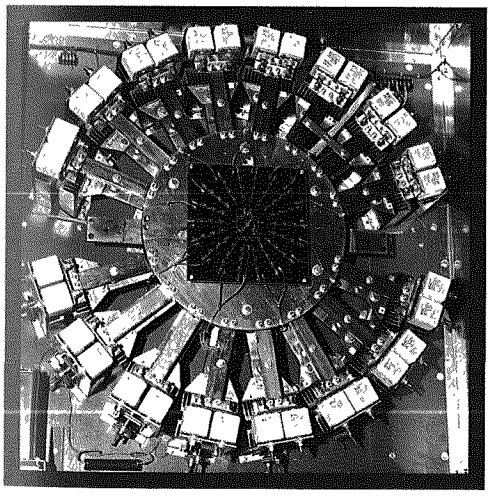
## Technical Specifications

| | |
|---|---|
| POWER RATINGS: | To 100 MW and higher (consult factory for specific configurations) |
| DESIGN: | Multi tier Pulse Width Modulated (PWM) |
| INPUT: | +10%, -5% at full power (Range: 380V - 34.5 kV, 50/60 Hz) |
| OUTPUT: | 0-6000 Volts; 0-100,000 Amps |
| INPUT POWER FACTOR: | Typically > .95 from 20-100% output voltage/power |
| INPUT POWER: | Non Phase Sequence Sensitive |
| RAMP-ON/RAMP-OFF RATE: | 0.4-60 sec. Adjustable (load dependent) |
| ENCLOSURE: | NEMA-1 Ventilated; NEMA-12 for Liquid Cooled Design<br>Outdoor power centers also available |
| AMBIENT TEMPERATURE: | 0-40° C |



## Power Rectifier Equipment with Digital Control



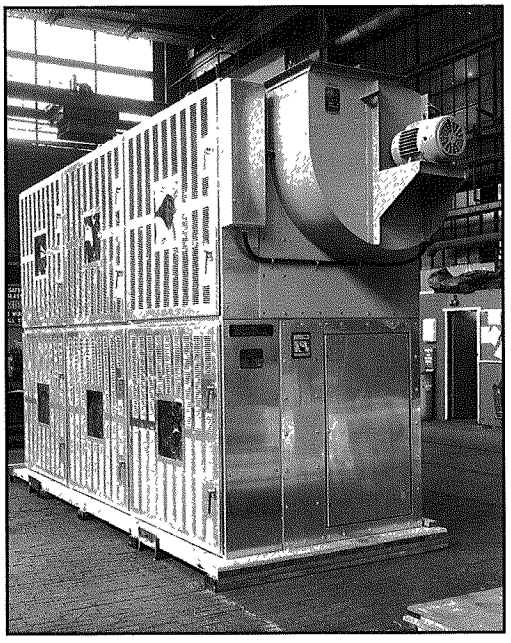


With more than 35 years of experience in building thyristor and diode rectifier equipment, some of the most innovative power rectifier solutions available are designed by Robicon

# "Proven Experience" Yields Benefit

Robicon has more than 35 years of experience building thyristor and diode rectifier equipment. Some of the most innovative designs available today come from Robicon.

The Robicon Canada facility has designed and built more than 2000 MW of power rectifier equipment in the last 10 years for service in:



Once-thru air-cooled rectifier

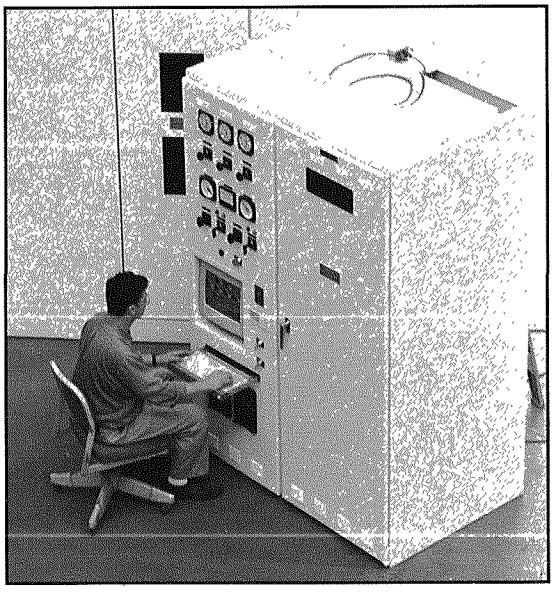
- Chlorine and sodium chlorate production
- Aluminum reduction
- Copper and zinc electrowinning
- Electrolytic refining
- DC arc furnace power supplies
- Hydrogen electrolysis
- High power test equipment
- Graphitizing

## Coaxial Design

Most Robicon rectifier systems (both air and liquid cooled) feature coaxial arrangement without additional arrangement of bus, semiconductors and fuses. This offers excellent current sharing without additional reactors or resistors.

## Digital Controls

- Complete digital system
- Self diagnostics
- Integral Programmable Logic Controllers (sequencer) are easily programmed by end user (programming and software included)
- Color monitor with:
  - Digital metering
  - Annunciator messages
  - Status indication
- Readily exchanged plug-in circuit cards
- All circuitry based on proven designs from motor drives, static excitation systems, Programable Logic Controllers and personal computers
- Software allows easy customization by Robicon or end users



## Lower Operating Costs

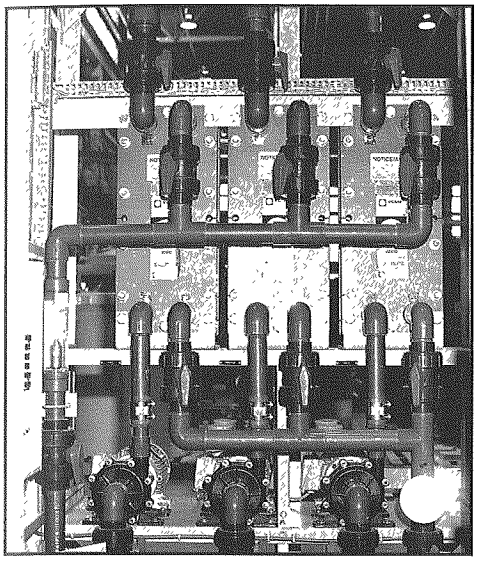
- High conversion efficiency rectifier systems available
- Extremely low maintenance
- All structural members are aluminum (except on low current units) greatly reducing eddy current and stray losses

## Accessability

Robicon rectifiers are designed to make the semiconductors and their protective fuses accessible and easy to change. Modern diode and thyristor construction and application practices make failure a rare occurrence.

## Leakproof Liquid Cooling Systems

Robicon liquid cooled rectifiers have a patented recirculating cooling system that runs continuously below atmospheric pressure. In the event of a leak, air is ingested, eliminating the risk of coolant leakage. This enables the system to be shut down for repair at an appropriate time without danger of a flashover caused by leaking water.



Sealless Magnetic Drive Recirculating Pumps and stainless steel plate-type Heat Exchangers in a water cooled unit

## 3 Main Types of Cooling

- **Convection Cooled** for extreme simplicity, reliability, negligible audible noise and low watt losses. Economically these are limited to lower current rectifiers.
- **Forced Air Cooled** systems can be once-thru untreated air, positive pressurization with filtered and/or chilled air, or totally enclosed systems with air-to-water heat exchangers. Water in the latter may be used once and then discharged, or it may be in a re-circulating system with a water-to-air heat exchanger outside of the rectifier.
- **Water Cooled** with a deionized, re-circulated, leak-protected water system. Water cooling allows for the highest density packaging of high current rectifiers.

## Control

- Fiber optic firing pulse connections to the rectifier eliminate electromagnetic interference
- Enclosures available range from outdoor control house to panels adapted to existing process control rooms
- Operator interfaces can be adapted to specific customer or process control requirements
- Process Control software can be programmed into the integral Programmable Logic Controller (sequencer), for example electrode control on DC arc furnace rectifiers
- Wide range of custom features can be provided in software
- Software supplied as standard enables user to change configurations using any IBM compatible personal computer

## Welded Buses

- All joints are welded except where installation and maintenance requirements demand bolted or clamped joints
- Welded joints ensure excellent conductivity and reliability, low losses, and virtually eliminate bus maintenance

## High Reliability

- Conservative semiconductor application
- Efficient, fail-safe cooling designs
- Digital controls and protection with proven backup protection
- Systems engineering capabilities to coordinate equipment and system requirements

## Configurations Available

- Rectifiers are usually supplied in bridge or single way and in 6 or 12 pulse configurations, depending on the requirements of the process and of the power system
- Other configurations are available upon request

## Custom Construction

- Housings may be supplied for indoor and outdoor applications
- Control, protection and instrumentation may be close coupled to the rectifier housing or mounted in remote locations

## Ratings

- Rectifiers can be supplied with any current and voltage rating required for the application, limited only by transformer size, shipping weight and dimensions
- Highest current supplied in one shipping section of a rectifier to date is 80,000 Amps
- Much higher currents are provided by connecting more than one rectifier section to a transformer

## Applicable Standards

Unit ratings are 100% continuous unless otherwise specified for a particular application. Design, rating and construction practices confirm to NEMA, ANSI, IEEE, EEMAC, IEC, and ISO 9001-1994.

## Partial List of Rectifier Equipment Shipped in Recent Years

| Customer | Location | Rated Amps | Output Volts | Application |
|---|---|---|---|---|
| Centromin* | Peru | 28,000 (2x14,000) | 800 | Copper |
| Huron Tech | Georgia, USA | 20,000 | 685 | Chlorate |
| Clecim* | Baoshan, China | 108,000 (3x36,000) | 40 | DC Arc Furnace |
| Noranda* | Missouri, USA | 22,000 | 40 | Aluminum |
| GE Plastics* | Indiana, USA | 88,000 (2x44,000) | 348 | Chlorine |
| Deutsche Voest Alpine* | Minnesota, USA | 120,000 (4x30,000) | 966 | DC Arc Furnace |
| IMMSA | Mexico | 84,000 (2x42,000) | 725 | Zinc |
| Controlled Power Corpn. | New York, USA | 9,600 | 625 | DC Substation |
| ALCAN (Phase 1) | Quebec, Canada | 280,000 (8x35,000) | 1065 | Aluminum |
| Alby Chlorates | Quebec, Canada | 60,000 | 310 | Chlorate |
| Albright & Wilson | B.C., Canada | 110,000 (2x55,000) | 420 | Chlorate |

** Digital Control*

This is only a partial list. An expanded list will be supplied upon request.

Robicon provides one of the most diverse and flexible ranges of solutions available in low voltage motor control.

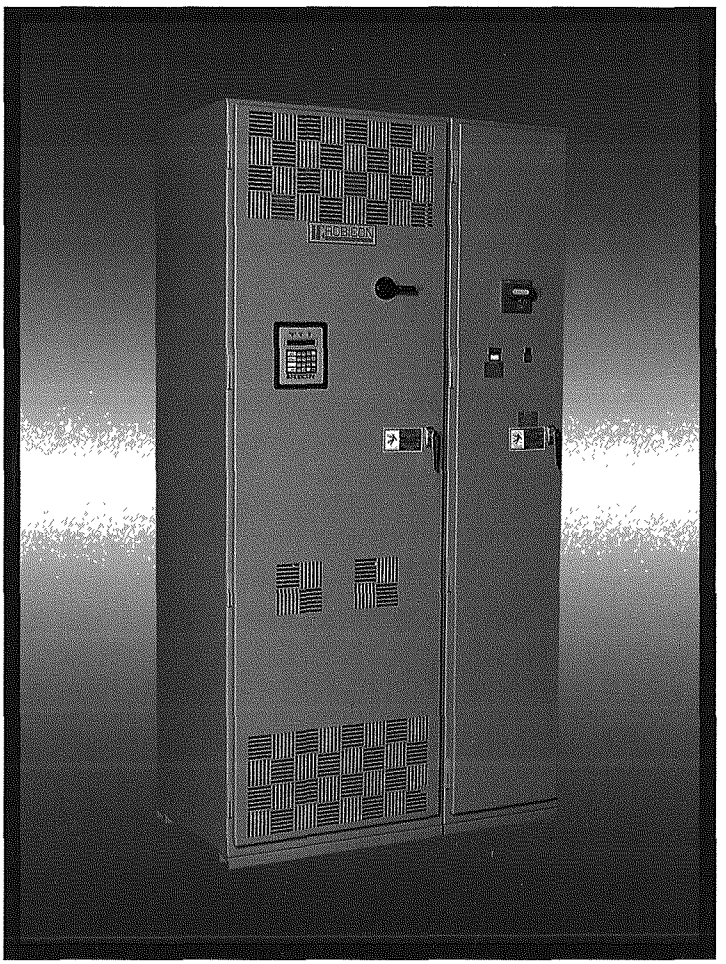
Solutions up to 1500 HP include PWM drives, which inherently correct nearly all input harmonics and overall power factor, and current source designs that deliver full load regeneration.

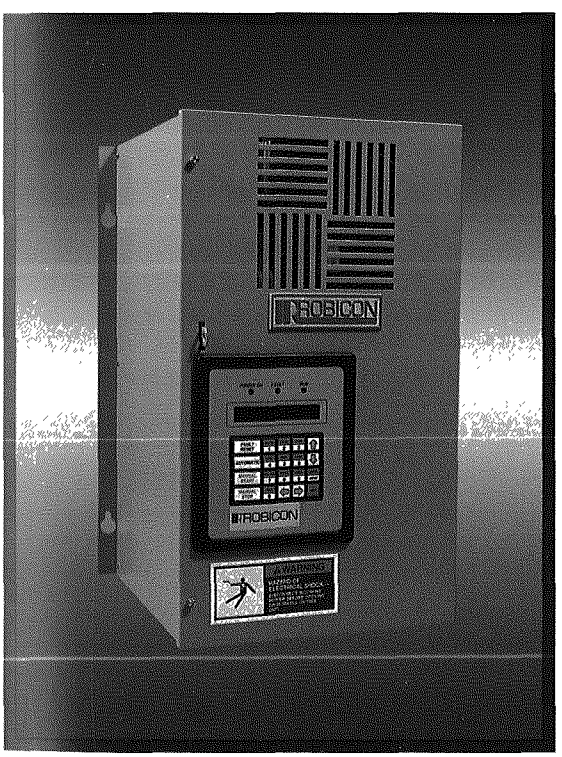
All drives come standard with Robicon's renowned user-friendly interface and an input line reactor that lowers voltage harmonic distortion and protects the entire inverter from input transients.

# 454 GT Series

## ID-PWM AC Low Voltage Variable Frequency Drives

| | | |
|---|---|---|
| 3 HP-800 HP | 208 VAC | 230 VAC |
| | 380 VAC | 415 VAC |
| | 460 VAC | 480 VAC |




This compact, user-friendly drive series uses space vector modulation and IGBT technology to deliver an efficient and cost-effective solution.





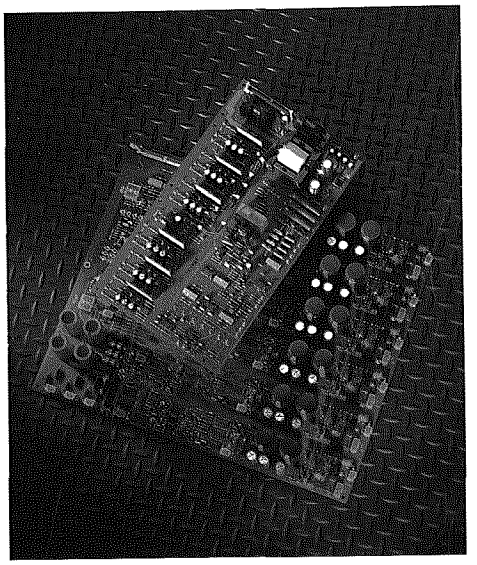
IP7_024769

# Technological Innovations

This drive series makes use of the latest IGBT technology: space vector modulation and surface mount construction to deliver benefits which save space, time and money. The 454 *GT* is available in standard units, with pre-engineered options or custom units.

## Space Vector Modulation

The 454 *GT* Series utilizes advanced PWM space vector modulation technology, resulting in lower output harmonics, smooth performance and extremely quiet motor operation. Space vector modulation actually "spreads out" sound energy over a wide range of frequencies. Given typical inverter-duty motor insulation, motor noise is much less problematic.



## IGBT Technology

At the heart of the 454 *GT* Drive Series is sophisticated IGBT (Insulated *Gate Bipolar Transistor*) technology. This technology enables these drives to deliver greatly enhanced performance capabilities.

- Higher carrier frequencies — IGBTs enable a much higher switching rate
- Extremely quiet motor operation — Higher switching frequencies and lower harmonic content enable motors to run quieter than ever before
- Higher motor efficiencies — IGBT technology provides operational efficiencies which result in improved performance
- Lower harmonic output content — The lower peak and harmonic currents result in cooler running motors and longer motor life, providing more usable torque through the entire speed range

## Auto Tuning

This feature delivers automatic tuning from the users point of view. Without decoupling the load a systematic tuning procedure is performed by simply pressing a button after the motor nameplate data is entered. A feedback controller measures inductance and resistance, and profiles the motor. This feature provides the precise control needed in some applications such as positive displacement pumps, extruders, mixers and conveyors.

# Performance Capabilities

## Motor Cable Lengths

In many industrial applications, a VFD and the motor it drives are separated by tens or hundreds of feet, which requires long cables called motor leads, to connect the two together. Fast-changing PWM voltage pulses can interact with the distributed inductance and capacitance of the motor leads, which can result in an amplified peak voltage as high as 1600 volts at the motor terminals. This is known as the long-lead effect. It can stress and degrade the insulation around the stator windings of the motor and lead to premature motor failure. These problems typically occur at leads of 50 feet or greater. Recommended solutions call for a reduction of lead length or in the switching frequency of the drive. Robicon Clean Power and 454GT VFDs are designed to minimize cable resonance problems. These drives are factory set for variable carrier frequencies, longer underlap times and asynchronous switching patterns. As a result, cable runs of 300 feet present no problems. Cable runs of 600 feet are possible with an optional output line reactor.

## Motor Compatibility

Robicon has been conducting motor-inverter compatibility tests since the 1980s. Our 454 *GT* Series, with its software switching patterns and standard hardware, is designed to reduce subsequent motor dV/dT problems. The space vector waveform of the 454 *GT* Series minimizes cable resonance. It is factory set for longer underlap times, asynchronous switching patterns, and permits only one leg to switch at a time. As a result, motor insulation problems due to dV/dT are much less problematic and output line reactors are rarely required.

## Standard Input Line Reactor

An AC input line reactor provides attenuation of line side transients, reduced input current harmonics and RFI suppression. It meets IEEE 587 for transient surge protection. It reduces RMS currents in DC bus capacitors, guards against single phase and/or phase unbalanced and protects the entire drive. Most manufacturers supply line reactors as an option needed only when the source impedance is greater than 10x the drive rating. However, many times a user can't predict the source impedance. Robicon takes a solution approach. An input line reactor is mounted and wired on all 454GT and Clean Power drives.

## Surface Mount Technology

The *454 GT* drives are manufactured using surface mount technology. The physical rigidity of the component cluster is enhanced, making for a more compact system because the circuit board can stand up better to the shock and stress of continuous operation. The reliability of the entire circuit board is improved.

- Superior reliability
- Smaller size
- Lower cost, higher efficiency

## DC Bus Control

Decelerating high inertia loads is a challenge for most drive systems because it creates a regenerative action causing the DC bus voltage to rise up until an overvoltage fault occurs. Typically, the user foregoes meeting process requirements by allowing an extended deceleration, or adds a dynamic braking module that wastes energy. Both options essentially defeat the purpose of installing a drive.

Robicon offers a low cost, high efficiency approach. This feature provides the fastest deceleration rate without adding a dynamic braking module. The Robicon 454GT and Clean Power series monitor the incoming voltage and the DC bus voltage and automatically extend deceleration rates as needed to decelerate the load. This allows the load to provide a quick deceleration rate initially. Deceleration rates are then automatically extended as necessary when load disappears and inertia remains.

## Overspeed Protection

Drives of all types are capable of speed ranges (0 to 400Hz) which exceed motor ratings. Robicon includes an overspeed parameter adjustment to assure that a speed beyond rated results in a trip. Refer to NEMA MG1 tables for maximum motor speeds.

## Underload Protection

Pumps depend upon a minimum flow in order to provide adequate lubrication and cooling. In previous years, minimum speeds were established in order to make certain that minimum flow conditions were met. Problems such as "air lock" or reduced flow due to high pressure conditions were not addressed and in many cases were unobserved. High maintenance and wear and tear on pump pieces would simply occur with no explanation.

An "underload protection" feature is standard in this drive line. With a minimum load threshold, the feature assures a minimum flow of fluid. Should a pump become air locked, or should flows reduce below minimum, a built-in timer will activate and shut the drive down to protect the total system.

## Microprocessor Control

These microprocessor drives operate with standard three-phase, AC induction motors and are designed to interface with a wide range of programmable controllers and computers via the optional serial communications port. The series has adjustable carrier frequencies that provide low motor noise. The drive comes with a state-of-the-art, 16-bit microprocessor with easy instructions.

## High Efficiency

With the advantages of IGBT technology, the typical operating efficiency is 97%-98%.

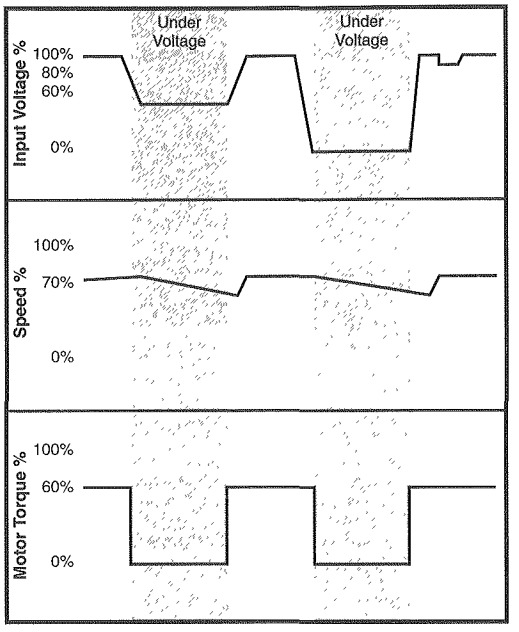
## High Power Factor

This series achieves .95 power factor throughout the entire speed range — without external power factor correction capacitors. This provides many benefits including eliminating penalties for poor power factor and improving voltage regulation.

# Trip-Free Operation

The *454 GT* Series can ride through a significant voltage dip or power loss.

- Improved undervoltage performance — This drive is designed to operate on imperfect power systems which have occasional undervoltage and power loss conditions. Under many applications the drive will continue to operate the motor, even with a 40% undervoltage, though output speed may be reduced during the undervoltage period.
- Regeneration power loss ridethrough — To prevent nuisance tripping, these drives will permit the motor to coast through total power loss or undervoltages greater than 40%. The drive utilizes system inertia and continues to gate power devices until the motor reaches 10% speed. When power is restored, both drive and motor begin producing torque, thus eliminating any time delays.
- 5 cycle ride through.




## Auto Restart

This drive series includes an auto-restart feature in which the operator can pre-select from the following parameters:

- Number of restarts (0 - 9)
- Time between restarts (1 sec - 300 sec)
- Restart to type of default (undervoltage, overtemperature, overvoltage, etc.)

## Single Phase Protection

In any voltage source drive, single phase conditions can and do occur during voltage unbalance conditions. It does not require a complete loss of phase for this condition to appear. 454GT and Clean Power Drives are capable of operation under single phase input conditions at reduced outputs. Current transformers are used to sense input currents. These signals are input to the gate board where a precision rectifier circuit is used to develop a control signal proportional to do bus current. This signal is sent to the microprocessor board where it is monitored for both average and peak levels. During single phase operation, the peak current levels will increase to a level where the microprocessor board will then automatically reduce its output speed and voltage in an attempt to keep input currents below rated rms values. This allows the system to continue to run safely but at a reduced output power level.

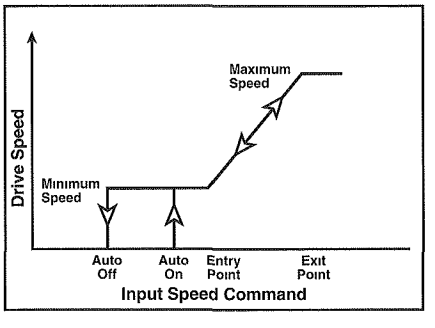
## AC Injection Braking

In many cases, fans that are not being driven tend to spin either forwards or backward due to induced drafts. Catch-a-spinning-load is common for forward spinning motors. However, backward spinning loads are more difficult to catch.

When catch-a-spinning-load is engaged, it automatically applies AC Injection Braking to power the load to a forward position, bring it to set speed and catch it. This feature eliminates the need for add-ons such as dynamic braking or regenerative modules.

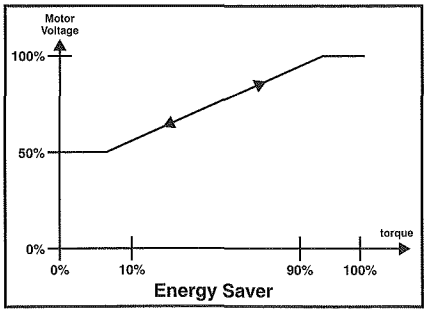
## Speed Profile

Provides individual adjustable settings.



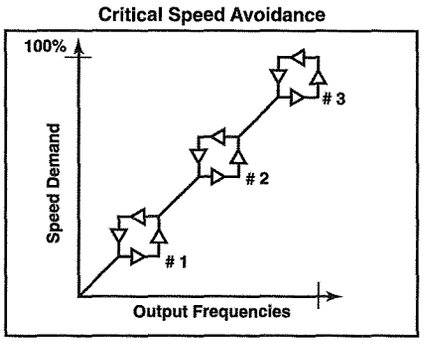

## Energy Saver

This feature sets the inverter output voltage as a function of the motor load, providing maximum motor efficiency over a wide range of load and duty cycles. This parameter specifies a minimum output motor voltage. A value of 50% represents a maximum energy savings potential, while a value of 100% represents no energy savings potential.



## Additional Performance Features

- Speed droop on overload
- Preset speeds: software selectable
- Catch-a-spinning-load
- PID control algorithm
- Critical speed avoidance
- Loss of control signal




# Reliability

## Proven Technology

Proven, state-of-the-art, IGBT and space vector technologies assure maximum reliability, even in adverse operating conditions. The simple configuration provides more drive value per dollar than any other on the market.

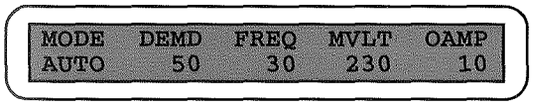
## Standard Protection Features

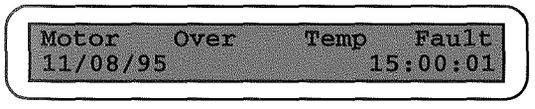
- Phase-loss protection
- Input fuses (200,000 AIC)
- Instantaneous overcurrent
- Input line undervoltage trip
- Overtemperature
- Input line reactor for input voltage transient protection
- Overcurrent
- Continuous ground fault
- Short circuit protection
- Electronic motor overload protection
- Overvoltage

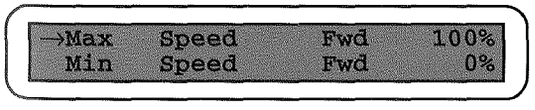
# Advanced Microprocessor Features

## Simple Keypad Entry

Commands and parameter settings are made by entering information on the drive's numeric keypad. No separate terminals or modules are required for programming or troubleshooting. This eliminates potentiometer adjustments and operator "judgment" settings. The LCD display will show current, voltage, % speed, Hz, RPM, kW, kW/hr, DC bus volts, % rated torque and elapsed time.




# Reports and Diagnostics

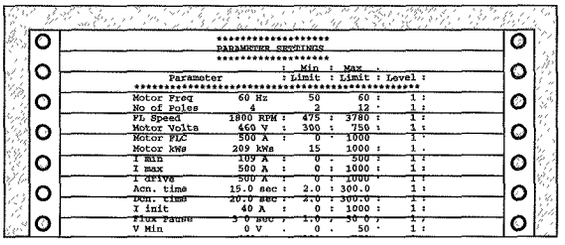
## Advanced Diagnostics

Diagnostic routines are built into the control circuits. Separate personal computers and auxiliary equipment are not required for diagnostic capabilities. Comprehensive monitoring of drive control functions and a display of all system faults are shown on the keypad/display module. This provides easy and extensive troubleshooting with the drive door closed. Historical record logs offer valuable operating information on events preceding a fault. Remote diagnostic capability is available via an optional modem connection.

## Reports

Reports are stored in non-volatile memory and contain valuable operating information and diagnostic data.

- Parameter log
- Fault log
- Historic log
- Diagnostic log




## Year 2000 Readiness

Robicon engineers have proactively addressed the impact of the Year 2000. The date on all Robicon drives is displayed in the format MM/DD/YY. Internally, the century digits are not maintained. No calculation or comparison is done on any Robicon system using the day or year. The largest increment of time that is significant to any Robicon drive is one hour, which is independent of the day, month and year. The time component is used for elapsed time functions. The year and day are used for logging functions only. For a complete disclosure of Robicon's Y2K readiness, visit www.robicon.com.

# User Friendly Operator Interface

## Keypad/Display Module

The *454 GT* Series provides precise and repeatable parameter setting and adjustments. All values are entered via the numeric keypad in engineering units.


## Security Code System

Fully programmable, multi-level, password-coded security system assures that entry will be achieved by authorized personnel only.

## Digital Display

The keypad/display has a full alphanumeric character set. The display has two lines of 24 characters for messages regarding system status and parameter adjustments.

## On-Line Operation While Tuning

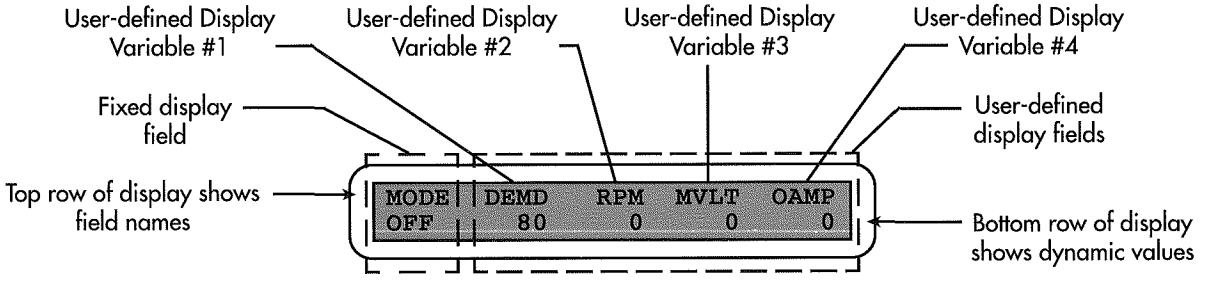
Parameter adjustments can be made while drive is operating. Other application specific items can be tuned on-line.

## User Friendly Messages

Avoids codes and translating. All messages are in text.

## Dynamic Programmable Meter Display

The meter display contains four user-defined display fields which can be programmed from the keypad. A pick list contains variables that can be displayed on the front panel LCD.




## Pick List Summary

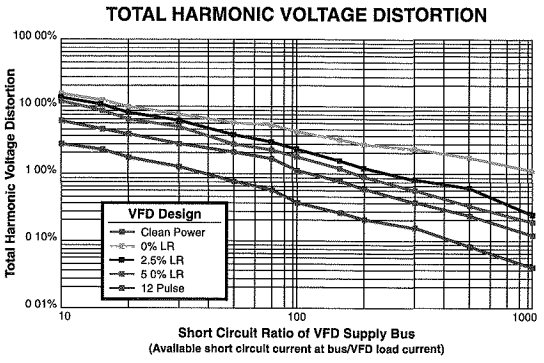
| Display Variable Name | Abbr |
|---|---|
| Motor Operating Frequency | FREQ |
| Motor Speed in RPM | RPM |
| Motor Speed in Percent | %SPD |
| Output Current | OAMP |
| Input Current | IAMP |
| Output Power in kW | kW |

| Display Variable Name | Abbr |
|---|---|
| Speed Reference | SREF |
| Motor Voltage | MVLT |
| Vdc | VDC |
| Line Voltage | VAV |

# Power and Control Options

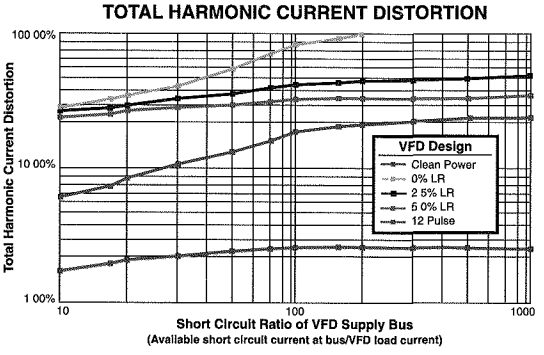
## Clean Power Input Option

To eliminate lower order line harmonics these drives can be supplied with Clean Power input rectifiers and transformers. This option enables the drive to inherently meet IEEE 519 1992 standards for both voltage and current distortion. See Clean Power section of catalog or consult factory.




## Constant Torque/Sensorless Vector Control

To realize the benefits of sensor vector control without the cost and maintenance of an encoder, Robicon provides sensorless vector control. This option raises the level of performance by allowing for general purpose constant torque drive system applications without encoder feedback. This option promotes fast response to main power line fluctuations and process side changes. This, combined with improved control with high starting torque or high torque at low speeds, can lead to higher overall motor and drive efficiency.




Hall effect sensors and sensorless vector software algorithms provide constant torque adjustable voltage and adjustable frequency control that is quiet, responsive, precise and simple. Drives with this option offer starting torque of 150%, automatic torque boost across the full range and a controlled speed range of 50:1. Dynamic braking is optional.

The sensorless vector control option is available in the full family of existing 454GT and Clean Power drives including all power ranges, voltage levels and line converter configurations.

## Power Options

- Clean power input
- Input disconnect
- Auto bypass
- Output line reactor
- Input circuit breaker
- Contactor constant speed bypass
- VFD output contactor
- Dynamic braking

# Communication and I/O Options

## Industry Standard Communication

The 454 *GT* has a microprocessor-based digital controller which offers more communications capability than any other drive of its kind.

The series can directly interface with many industry-standard communications systems and digital control schemes. Options include:

- Modbus-Plus™
- Modicon Modbus™
- Allen-Bradley DH™, DH+™
- Reliance AutoMAX™, AutoMATE™
- PROFIBUS DP™
- DeviceNet™
- Siemens SIMATIC/TI505™
- Diagnostic modem
- Johnson Controls Metasys™
- GE Genius™
- Ethernet Modbus™
- Other Programmable Logic Controller and serial interfaces available on request

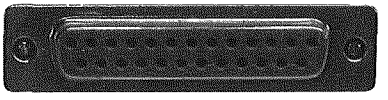
### Input/Output Capability

The 454 *GT* Series offers I/O capabilities in either digital or analog.

- Two **isolated** two-wire analog inputs individually software configurable as either 4-20 mA, 0-20 mA or 0-10 V
- Two programmable **isolated** two-wire analog outputs 4-20 mA, individually software configurable as speed, voltage or current
- Seven programmable, digital inputs, internally-derived 24 VDC non-isolated
- Three programmable form C relay digital outputs (dry contact)
- One programmable, 0-10 V non-isolated potentiometer input
- One system E-stop digital input, internally-driven 24 VDC non-isolated

### Standard Cable Connections

A standard DB25 cable enables easy connections with PCs and printers through our standard isolated serial port. These cables are available at most computer retailers.



# Service and Support

### Sales & Application Engineers

Robicon has been manufacturing variable frequency drives for more than 30 years. Our engineers have many years of application-specific experience in industrial, municipal and HVAC markets and are strategically located at headquarters and regional offices. Assistance is also available through our network of manufacturer's representatives. Our representatives are the first step in developing a drives system solution that saves time and money.

### Technical Support Center

Associates at our 24-hour help line (724-339-9501) provide immediate telephone assistance for customers needing help with troubleshooting, programming, installation or start-up. Our contact management computer system enables our associates to assure continuity of your dialogue and provide fast and accurate solutions.

### Field Service Representatives

Field service representatives provide 24-hour emergency response around the world from 50 locations in addition to Robicon's factory. Our field service representatives are specifically trained to handle every phase of installation, start-up, maintenance and troubleshooting of Robicon drives and to take full advantage of Robicon's extensive technical and operational resources.

### Commitment Management

Robicon's process-based order fulfillment places sales and project engineers on the same team to ensure all aspects of our commitment and diligent follow-through on your order.

### Factory Repair, Parts, Exchanges

Associates provide turnaround on repairs for most items in 24 hours. Exchanges are available to maximize uptime. Spare parts are held in strategic locations to provide same-day delivery, and spare part kits are available to ensure critical applications.

### Warranty

Unlike many drives manufacturers, Robicon's warranty covers all on-site and in-house repairs, labor, materials and expenses.

### Technical Training

User Training Programs teach customers how to operate and maintain Robicon drives. These programs are conducted at customer sites and at Robicon's factory training center. Classes cover every drive configuration with basic and advanced courses for design, operation and maintenance personnel.

## Technical Specifications

| | |
|---|---|
| HP RANGE: | Lower limit 3 HP; upper limit 800 HP |
| INPUT: | 208, 230, 380, 415, 460, 480 VAC ± 10% |
| INPUT POWER FACTOR: | .95 Displacement Power Factor at all operating speeds |
| VFD EFFICIENCY (FULL POWER): | 98% |
| FREQUENCY DRIFT: | ± 0.5% |
| VOLTAGE REGULATION: | ± 1% Rated Value, No Load to Full Load |
| SPEED REGULATION: | 3% (motor dependent) |
| SPEED RANGE: | 40:1 (variable torque) 50:1 (sensorless vector control) |
| CONTROL CIRCUITS: | 24 VDC |
| DESIGN: | Voltage Source, Pulse Width Modulated Space Vector |
| AMBIENT TEMPERATURE: | 0 - 40°C |
| ALTITUDE: | Maximum 3300 Feet Above MSL |
| CURRENT LIMIT: | 50% - 120% Variable Torque<br>50% - 150% Constant Torque |
| ACCELERATION RATE: | 1 - 3200 Sec. Selectable |
| DECELERATION RATE: | 1 - 3200 Sec. Selectable |
| CURRENT CAPACITY: | 100% Continuous<br>120% for 1 minute variable torque<br>150% for 1 minute sensorless vector |
| STARTING TORQUE CAPACITY: | 150% for 1 minute (with sensorless vector option) |
| INPUT SPEED COMMAND: | Isolated 2 Wire, 4 - 20 mA Optional 3-15 PSI transducer<br>Isolated 2 Wire, 0 - 10 VDC<br>0 - 10 V potentiometer |
| ANALOG OUTPUTS: | Isolated 2 Wire, 4 - 20 mA, Programmable |
| OUTPUT FREQUENCY: | 0 - 400 Hz (consult factory for applications above 120 Hz) |
| ELECTRONIC REVERSING: | Standard |
| JOGGING CAPABILITY: | Forward and Reverse |
| POWER LOSS RIDE-THROUGH: | 5 cycles |
| CONTROL POWER RIDE-THROUGH: | 2 seconds |
| INERTIA RIDE-THROUGH: | Load dependent |
| AUTOMATIC RESTART AFTER POWER LOSS: | Selectable |
| AUTOMATIC RESTART ON RE-SETTABLE TRIP: | Adjustable — 0 to 9 attempts |
| CRITICAL FREQUENCY REJECTION: | Adjustable bands — selectable - 3 |
| STALL PROTECTION: | Current limited — Acceleration, deceleration and run |
| RESTART INTO SPINNING MOTOR: | Synchronized |
| SLIP COMPENSATION: | Automatic |
| DYNAMIC BRAKING: | Optional |
| AUTOTUNING: | Standard |
| ENCLOSURE: | Chassis, NEMA-1, NEMA-12 Ventilated |
| SERIAL PORT: | Isolated RS232/422/485 jumper selectable |
| AGENCY APPROVALS | UL, CUL (Most configurations) |

## 454GT (480VAC) Overall Parameters

| Nominal HP 460Vac | VT / CT Amps | | Max Losses | | Req'd CFM | Chassis Size (H x W x D) | Chassis Weight (lbs.) | Drive w/Op Size (H x W x D) | Drive w/Op Weight (lbs.) | Drive w/Bypass (H x W x D) | Drive w/Bypass Weight (lbs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kw | BTU/hr | | | | | | | |
| 3 | 5 | 4.8 | 0.09 | 306 | 16 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 5 | 8 | 7.6 | 0.14 | 484 | 25 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 7.5 | 12 | 11 | 0.21 | 700 | 36 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 10 | 15 | 14 | 0.26 | 891 | 46 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 15 | 23 | 21 | 0.39 | 1,337 | 69 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 20 | 30 | 27 | 0.5 | 1,719 | 89 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 25 | 37 | 34 | 0.63 | 2,164 | 112 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 30 | 44 | 40 | 0.75 | 2,546 | 131 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 40 | 57 | 52 | 0.97 | 3,310 | 171 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 50 | 72 | 65 | 1.21 | 4,137 | 213 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 60 | 85 | 77 | 1.44 | 4,901 | 253 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 75 | 106 | 96 | 1.79 | 6,111 | 315 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 100 | 136 | 124 | 2.31 | 7,893 | 407 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 450 | 72 x 30 x 20 | 600 |
| 125 | 172 | 156 | 2.91 | 9,930 | 512 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 500 | 72 x 30 x 20 | 650 |
| 150 | 198 | 180 | 3.36 | 11,457 | 591 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 550 | 72 x 30 x 20 | 700 |
| 200 | 264 | 240 | 4.48 | 15,277 | 788 | 51 x 17 x 20 | 180 | 54 x 30 x 21 | 600 | 72 x 30 x 20 | 750 |
| 250 | 330 | 300 | 5.6 | 19,096 | 985 | 51 x 17 x 20 | 180 | 54 x 30 x 21 | 650 | 72 x 30 x 20 | 800 |
| 300 | 393 | 360 | 6.71 | 23,110 | 1,182 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 350 | 462 | 420 | 7.83 | 26,961 | 1,379 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 400 | 528 | 480 | 8.95 | 30,813 | 1,576 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 450 | 594 | 540 | 10.07 | 34,664 | 1,772 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 500 | 660 | 600 | 11.19 | 38,516 | 1,969 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 600 | 792 | 720 | 13.43 | 45,830 | 2,363 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |
| 700 | 924 | 840 | 15.67 | 53,468 | 2,757 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |
| 800 | 1,056 | 960 | 17.9 | 61,106 | 3,151 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |

NA: Not Available
CF: Consult Factory
3-250Hp specifications are for wall mount enclosures.
Also available in Floor Standing NEMA 1 enclosures.

## 454GT (415VAC) Overall Parameters

| Nominal CT 415Vac Motor KW | Nominal VT 415Vac Motor KW | CT / VT Amps | | Max Losses | | Req'd CFM | Chassis Size (H x W x D) | Chassis Weight (lbs.) | Drive w/Op Size (H x W x D) | Drive w/Op Weight (lbs.) | Drive w/Bypass (H x W x D) | Drive w/Bypass Weight (lbs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kw | BTU/hr | | | | | | | |
| 1.5 | 2.2 | 4.8 | 5 | 0.09 | 306 | 16 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 3.0 | 3.0 | 7.6 | 8 | 0.14 | 484 | 25 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 4.0 | 5.5 | 11 | 12 | 0.21 | 700 | 36 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 5.5 | 5.5 | 14 | 15 | 0.26 | 891 | 46 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 7.5 | 11.0 | 21 | 23 | 0.39 | 1,337 | 69 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 11.0 | 11.0 | 27 | 30 | 0.5 | 1,719 | 89 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 15.0 | 18.5 | 34 | 37 | 0.63 | 2,164 | 112 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 18.5 | 22.0 | 40 | 44 | 0.75 | 2,546 | 131 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 22.0 | 22.2 | 52 | 57 | 0.97 | 3,310 | 171 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 30.0 | 37.0 | 65 | 72 | 1.21 | 4,137 | 213 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 37.0 | 37.0 | 77 | 85 | 1.44 | 4,901 | 253 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 45.0 | 55.0 | 96 | 106 | 1.79 | 6,111 | 315 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 55.0 | 55.0 | 124 | 136 | 2.31 | 7,893 | 407 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 450 | 72 x 30 x 20 | 600 |
| 75.0 | 90.0 | 156 | 172 | 2.91 | 9,930 | 512 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 500 | 72 x 30 x 20 | 650 |
| 90.0 | 110.0 | 180 | 198 | 3.36 | 11,457 | 591 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 550 | 72 x 30 x 20 | 700 |
| 132.0 | 132.0 | 240 | 264 | 4.48 | 15,277 | 788 | 51 x 17 x 20 | 180 | 54 x 30 x 21 | 600 | 72 x 30 x 20 | 750 |
| 160.0 | 160.0 | 300 | 330 | 5.6 | 19,096 | 985 | 51 x 17 x 20 | 180 | 54 x 30 x 21 | 650 | 72 x 30 x 20 | 800 |
| 200.0 | 200.0 | 360 | 393 | 6.71 | 23,110 | 1,182 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 200.0 | 200.0 | 420 | 462 | 7.83 | 26,961 | 1,379 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 250.0 | 250.0 | 480 | 528 | 8.95 | 30,813 | 1,576 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 315.0 | 315.0 | 540 | 594 | 10.07 | 34,664 | 1,772 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 315.0 | 355.0 | 600 | 660 | 11.19 | 38,516 | 1,969 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 400.0 | 400.0 | 720 | 792 | 13.43 | 45,830 | 2,363 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |
| 450.0 | 500.0 | 840 | 924 | 15.67 | 53,468 | 2,757 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |
| 500.0 | 500.0 | 960 | 960 | 17.9 | 61,106 | 3,151 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |

NA: Not Available
CF: Consult Factory
3.7KW-160KW specifications are for wall mount enclosures.
Also available in Floor Standing NEMA 1 enclosures.

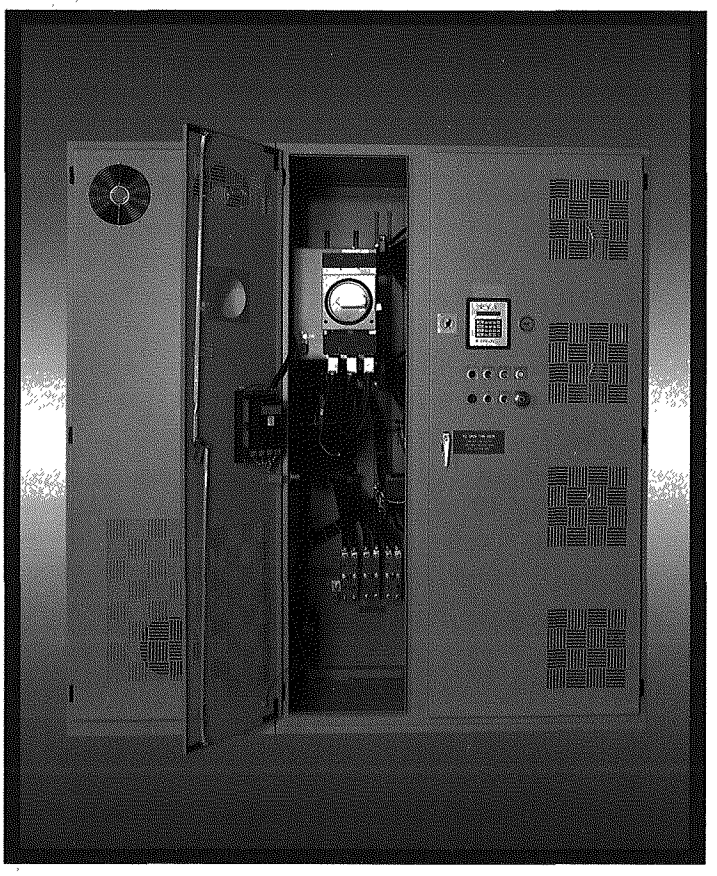
## 454GT (380VAC) Overall Parameters

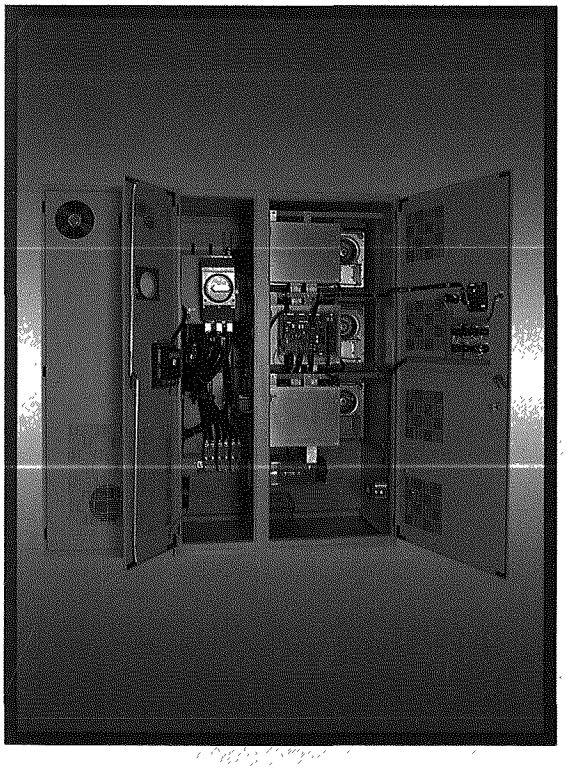
| Nominal CT 380Vac Motor KW | Nominal VT 380Vac Motor KW | CT / VT Amps | | Max Losses | | Req'd CFM | Chassis Size (H x W x D) | Chassis Weight (lbs.) | Drive w/Op Size (H x W x D) | Drive w/Op Weight (lbs.) | Drive w/Bypass (H x W x D) | Drive w/Bypass Weight (lbs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kw | BTU/hr | | | | | | | |
| 1.5 | 1.5 | 4.8 | 5 | 0.09 | 306 | 16 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 3.0 | 3.0 | 7.6 | 8 | 0.14 | 484 | 25 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 4.0 | 4.0 | 11 | 12 | 0.21 | 700 | 36 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 5.5 | 5.5 | 14 | 15 | 0.26 | 891 | 46 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 7.5 | 7.5 | 21 | 23 | 0.39 | 1,337 | 69 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 11.0 | 11.0 | 27 | 30 | 0.5 | 1,719 | 89 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 15.0 | 15.0 | 34 | 37 | 0.63 | 2,164 | 112 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 18.5 | 18.5 | 40 | 44 | 0.75 | 2,546 | 131 | 21 x 14 x 12 | 65 | 21 x 23 x 12 | 90 | 21 x 28 x 12 | 115 |
| 22.0 | 22.0 | 52 | 57 | 0.97 | 3,310 | 171 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 30.0 | 30.0 | 65 | 72 | 1.21 | 4,137 | 213 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 37.0 | 37.0 | 77 | 85 | 1.44 | 4,901 | 253 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 45.0 | 45.0 | 96 | 106 | 1.79 | 6,111 | 315 | 28 x 20 x 13 | 110 | 28 x 31 x 13 | 140 | 28 x 35 x 13 | 160 |
| 55.0 | 55.0 | 124 | 136 | 2.31 | 7,893 | 407 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 450 | 72 x 30 x 20 | 600 |
| 75.0 | 75.0 | 156 | 172 | 2.91 | 9,930 | 512 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 500 | 72 x 30 x 20 | 650 |
| 90.0 | 90.0 | 180 | 198 | 3.36 | 11,457 | 591 | 51 x 17 x 20 | 170 | 54 x 30 x 21 | 550 | 72 x 30 x 20 | 700 |
| 110.0 | 132.0 | 240 | 264 | 4.48 | 15,277 | 788 | 51 x 17 x 20 | 180 | 54 x 30 x 21 | 600 | 72 x 30 x 20 | 750 |
| 132.0 | 160.0 | 300 | 330 | 5.6 | 19,096 | 985 | 51 x 17 x 20 | 180 | 54 x 30 x 21 | 650 | 72 x 30 x 20 | 800 |
| 160.0 | 200.0 | 360 | 393 | 6.71 | 23,110 | 1,182 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 200.0 | 200.0 | 420 | 462 | 7.83 | 26,961 | 1,379 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 200.0 | 250.0 | 480 | 528 | 8.95 | 30,813 | 1,576 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 250.0 | 250.0 | 540 | 594 | 10.07 | 34,664 | 1,772 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 250.0 | 315.0 | 600 | 660 | 11.19 | 38,516 | 1,969 | 85 x 33.5 x 21 | 330 | 90 x 36 x 30 | 1100 | 90 x 60 x 30 | 1735 |
| 355.0 | 400.0 | 720 | 792 | 13.43 | 45,830 | 2,363 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |
| 400.0 | 450.0 | 840 | 924 | 15.67 | 53,468 | 2,757 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |
| 450.0 | 450.0 | 960 | 960 | 17.9 | 61,106 | 3,151 | NA | NA | 90 x 58 x 32 | 2000 | CF | CF |

NA: Not Available
CF: Consult Factory
3.7KW-160KW specifications are for wall mount enclosures.
Also available in Floor Standing NEMA 1 enclosures.

# ID-PWM AC Low Voltage Variable Frequency Drives

50 HP-800 HP 208 VAC 230 VAC
380 VAC 415 VAC
460 VAC 480 VAC





The Clean Power Series of AC Drives operate at near unity power factor, prevent harmonic problems and meet the requirements of IEEE 519 1992 at the drive input terminals.

# Power Quality Expertise

Robicon has been addressing harmonics since this issue came to the forefront in 1981. The Clean Power series is our fourth generation design and solves harmonics at the drive. It is available in standard units, with pre-engineered options or custom units. We're the only company with harmonics expertise at all levels: representative, regional manager and application engineer.

IEEE 519 1992 was written with considerable input from utilities to address the increase of non-linear loads being applied across industries. The Clean Power Series meets current distortion limits for the 5th, 7th, 11th and 13th harmonic according to Table 10.3 of IEEE 519 1992. The multi-pulse, phase-shifting design of the Clean Power series meets these requirements without additional harmonic filters.

Robicon is the only drives manufacturer who has consistently been serving municipal customers for over twenty years. As a result, Robicon has the largest installed base of drives in water and waste/water applications.

## Clean Power Input

The Clean Power Series prevents harmonic problems and exceeds the most stringent IEEE 519 1992 harmonic distortion requirements for both *voltage and current.*

- Does not introduce on-line harmonic disturbances
- Provides near zero harmonic level on Power System or Generator Systems
- Prevents cross-talk with other variable frequency drives
- Eliminates need for time-consuming harmonic analysis
- Avoids costly and inefficient harmonic filters and associated resonance problems

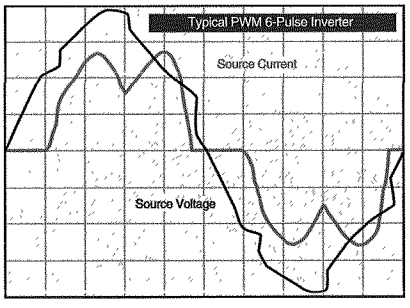
## High Power Factor

Provides near unity true power factor throughout entire speed range without external power factor correction capacitors. True power factor is a combination of distorted and displaced power factor. The Clean Power Series is one of few designs that corrects both.

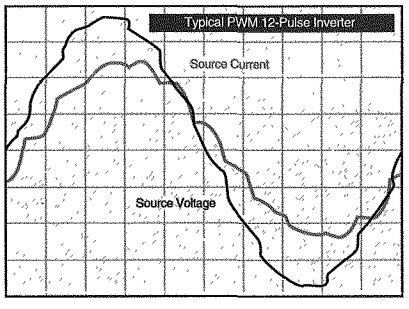
- Eliminates utility penalties for poor power factor
- Avoids overloading feeders, breakers and transformers with reactive power
- Improves voltage regulation
- Maintains a high and stable power factor throughout entire speed range using standard induction motors; ideal for low base speed motor applications

# Harmonic Comparison

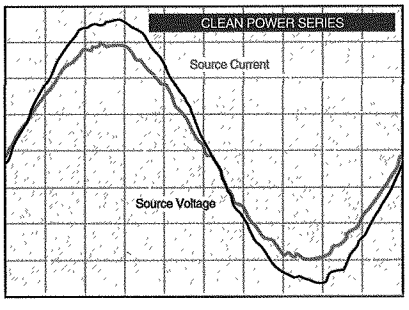
**HARMONIC COMPARISON OF TYPICAL 200 HP PWM INVERTER VS. CLEAN POWER DRIVE OPERATING FROM A 220 KVA, 5.75% IMPEDANCE SOURCE**




6-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 30.1% —*
*Total Harmonic Distortion (VOLTAGE) 8.1% —*

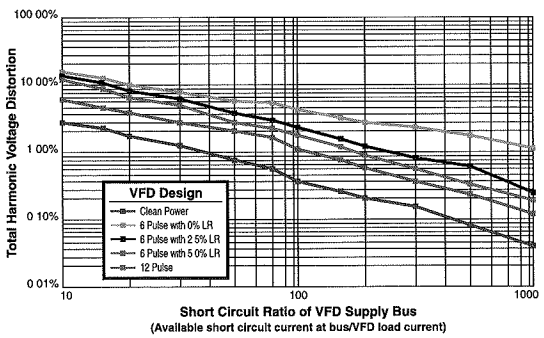



12-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 6.5% —*
*Total Harmonic Distortion (VOLTAGE) 5.2% —*

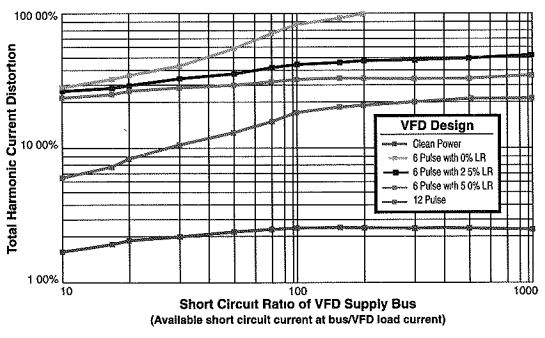



CLEAN POWER SERIES WAVEFORM
*Total Harmonic Distortion (CURRENT) 2.5% —*
*Total Harmonic Distortion (VOLTAGE) 2.9% —*

**TOTAL HARMONIC VOLTAGE DISTORTION**




**TOTAL HARMONIC CURRENT DISTORTION**




**Source: VFDNet™ (Robicon's harmonic analysis application)**



IP7_024782

## Space Vector Modulation

The Clean Power Series utilizes advanced PWM space vector modulation technology, resulting in lower output harmonics, smooth motor torque performance and extremely quiet motor operation. Space vector modulation actually "spreads out" sound energy over a wide range of frequencies. Given typical inverter-duty motor insulation, motor noise is much less problematic.

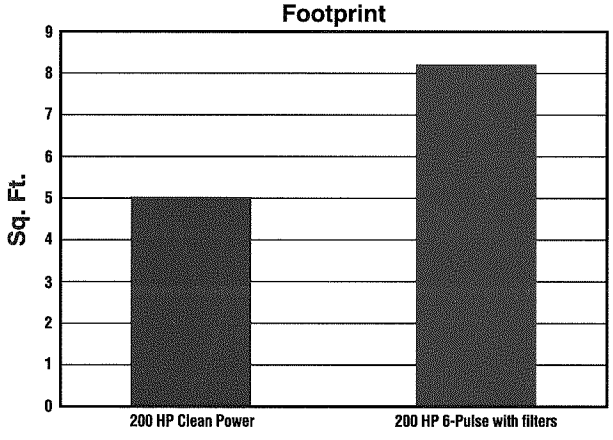
## IGBT Technology

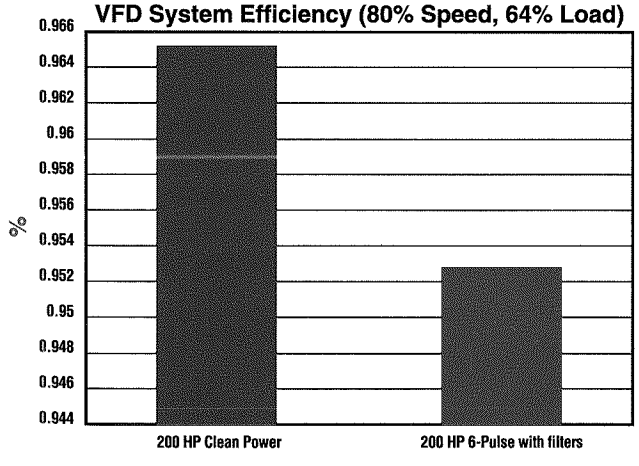
At the heart of the Clean Power Series is sophisticated IGBT (Insulated Gate Bipolar Transistor) technology.

- Higher carrier frequencies — IGBTs enable a much higher switching rate
- Extremely quiet motor operation — Higher switching frequencies and lower harmonic content enable motors to run quieter than ever before
- Higher motor efficiencies — IGBT technology provides operational efficiencies which result in improved performance
- Low harmonic output content — The lower peak and harmonic currents resulting from IGBT technology results in cooler running motors and longer motor life. This also provides more usable torque through the entire speed range

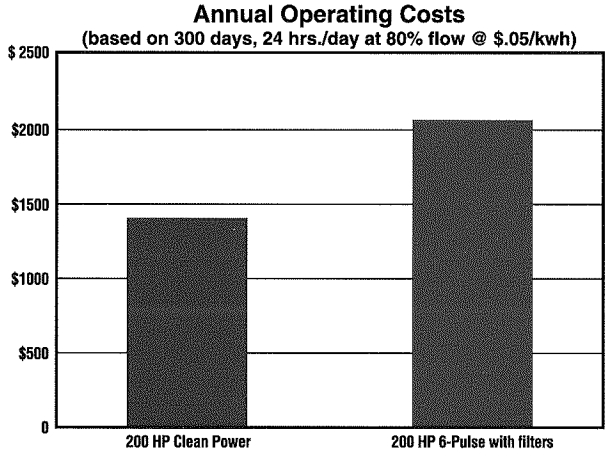
# Cost Comparison

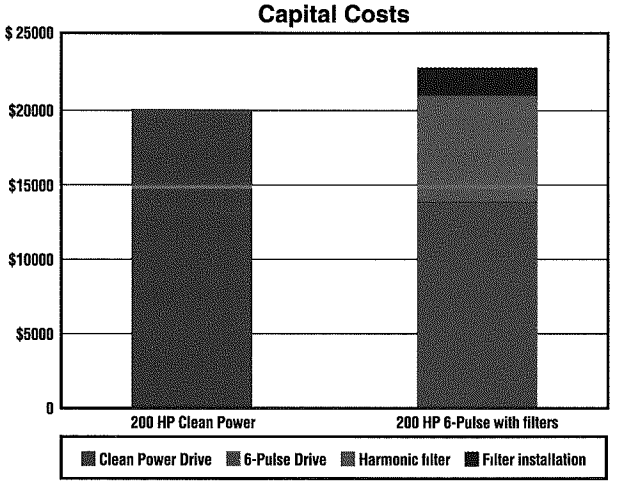
**SPACE REQUIREMENTS**—Compared to a 6-pulse VFD with harmonic filters, the Clean Power series has only one enclosure and requires less cable routing.




**OPERATING COSTS**—Additional losses from the harmonic filters make total losses of a 6-pulse VFD with filters higher than the Clean Power series.



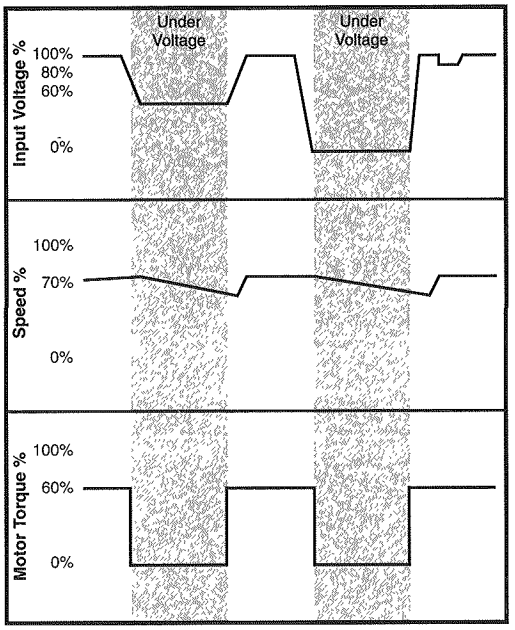

**COST**—The equipment cost for a 6-pulse VFD may seem less than a Clean Power series drive, but extra cabling and installation of harmonic filters make the real cost higher.

# Performance Capabilities

## Trip Free Operation

The Clean Power Series can ride through a significant voltage dip or power loss.

- Improved undervoltage performance — This drive is designed to operate on imperfect power systems which have occasional undervoltage and power loss conditions. Under many applications, the drive will continue to operate the motor, even with a 40% undervoltage, though output speed may be reduced during the undervoltage period.
- Regeneration power loss ride through — To prevent nuisance tripping, these drives permit the motor to coast through total power loss or undervoltages greater than 40%. The drive will continue to gate power devices and control the motor until it reaches 10% speed. When power is restored, both drives and motor instantaneously begin producing torque, thus eliminating any time delays.
- 5 cycle ride through.




## Auto Restart

This drive series includes an auto-restart feature in which the operator can pre-select from the following parameters:

- Number of restarts (0 - 9)
- Time between restarts (1 sec - 300 sec)
- Restart to type of default (undervoltage, overtemperature, overvoltage, etc.)

## Underload Protection

Pumps depend upon a minimum flow in order to provide adequate lubrication and cooling. In previous years, minimum speeds were established in order to make certain that minimum flow conditions were met. Problems such as "air lock" or reduced flow due to high pressure conditions were not addressed and in many cases were unobserved. High maintenance and wear and tear on pump pieces would simply occur with no explanation.

An "underload protection" feature is standard in this drive line. With a minimum load threshold, the feature assures a minimum flow of fluid. Should a pump become air locked, or should flows reduce below minimum, a built-in timer will activate and shut the drive down to protect the total system.

## Overspeed Protection

Drives of all types are capable of speed ranges (0 to 400Hz) which exceed motor ratings. Robicon includes an overspeed parameter adjustment to assure that a speed beyond rated results in a trip. Refer to NEMA MG1 tables for maximum motor speeds.

## Motor Cable Lengths

In many industrial applications, a VFD and the motor it drives are separated by tens or hundreds of feet, which requires long cables called motor leads, to connect the two together. Fast-changing PWM voltage pulses can interact with the distributed inductance and capacitance of the motor leads, which can result in an amplified peak voltage as high as 1600 volts at the motor terminals. This is known as the long-lead effect. It can stress and degrade the insulation around the stator windings of the motor and lead to premature motor failure. These problems typically occur at leads of 50 feet or greater. Recommended solutions call for a reduction of lead length or in the switching frequency of the drive. Robicon Clean Power and 454GT VFDs are designed to minimize cable resonance problems. These drives are factory set for variable switching frequencies, longer underlap times and asynchronous switching patterns. As a result, cable runs of 300 feet present no problems. Cable runs of 600 feet are possible with an optional output line reactor.

## Auto Tuning

This feature delivers automatic tuning from the users point of view. Without decoupling the load a systematic tuning procedure is performed by simply pressing a button after the motor nameplate data is entered. A feedback controller measures inductance and resistance, and profiles the motor. This feature provides the precise control needed in some applications such as positive displacement pumps, extruders, mixers and conveyors.

## Motor Compatibility

Robicon guarantees that its Variable Frequency Drives will operate any major manufacturer's standard induction motor. Contact the factory to discuss your application.

## Proven Technology

Proven, state-of-the-art, IGBT and space vector technologies assure maximum reliability, even in adverse operating conditions. The simple, less-complicated configuration provides more drive value per dollar than any other on the market.

## DC Bus Control

Decelerating high inertia loads is a challenge for most drive systems because it creates a regenerative action causing the DC bus voltage to rise up until an over-voltage fault occurs. Typically, the user foregoes meeting process requirements by allowing an extended deceleration, or adds a dynamic braking module that wastes energy. Both options essentially defeat the purpose of installing a drive.

Robicon offers a low cost, high efficiency approach. This feature provides the fastest deceleration rate without adding a dynamic braking module. The Robicon 454GT and Clean Power series monitor the incoming voltage and the DC bus voltage and automatically extend deceleration rates as needed to decelerate the load. This allows the load to provide a quick deceleration rate initially. Deceleration rates are then automatically extended as necessary when load disappears and inertia remains.

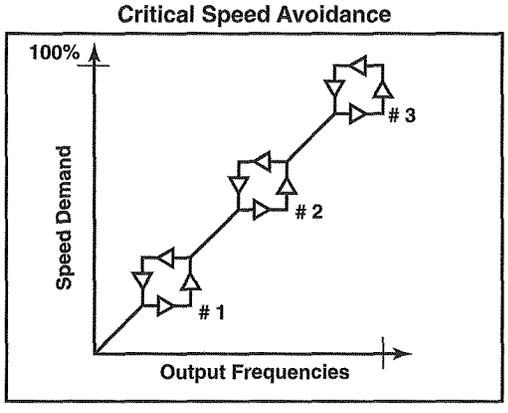
## Current Limit

Provides base setting, adjustable from keypad.

- 50 –150%

## Standard Protection Features

- Phase-loss protection
- Input fuses (200,000 AIC)
- Instantaneous overcurrent
- Input line undervoltage trip
- Overtemperature
- Input line reactor for input voltage transient protection
- Overcurrent
- Continuous ground fault
- Short circuit protection
- Electronic motor overload protection
- Overvoltage




## Testing

To ensure quality, all variable frequency drives are functionally tested on motors of equivalent horsepower rating. In addition, all VFDs are burned in with a full load, full power test. Additional testing is available per customer's specifications.

## Single Phase Protection

In any voltage source drive, single phase conditions can and do occur during voltage unbalance conditions. It does not require a complete loss of phase for this condition to appear. 454GT and Clean Power Drives are capable of operation under single phase input conditions at reduced outputs. Current transformers are used to sense input currents. These signals are input to the gate board where a precision rectifier circuit is used to develop a control signal proportional to do bus current. This signal is sent to the microprocessor board where it is monitored for both average and peak levels. During single phase operation, the peak current levels will increase to a level where the microprocessor board will then automatically reduce its output speed and voltage in an attempt to keep input currents below rated rms values. This allows the system to continue to run safely but at a reduced output power level.

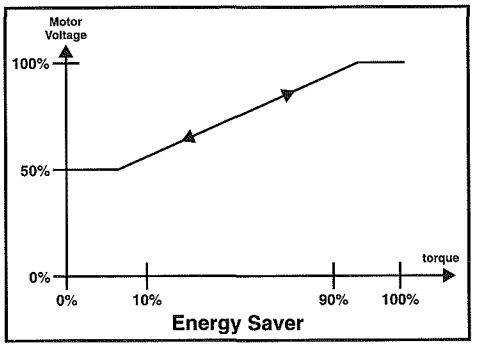
## AC Injection Braking

In many cases, fans that are not being driven tend to spin either forwards or backward due to induced drafts. Catch-a-spinning-load is common for forward spinning motors. However, backward spinning loads are more difficult to catch.

When catch-a-spinning-load is engaged, it automatically applies AC Injection Braking to power the load to a forward position, bring it to set speed and catch it. This feature eliminates the need for add-ons such as dynamic braking or regenerative modules.

### Energy Saver

This feature sets the inverter output voltage as a function of the motor load, providing maximum motor efficiency over a wide range of load and duty cycles. This parameter specifies a minimum output motor voltage. A value of 50% represents a maximum energy savings potential, while a value of 100% represents no energy savings potential.

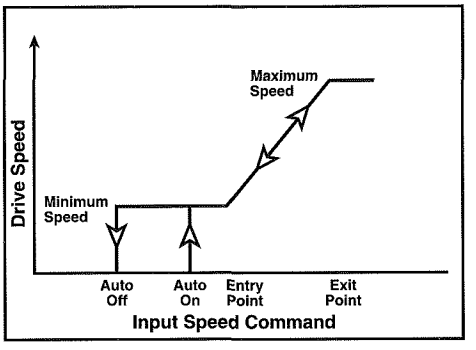



### Speed Profile

Provides individual adjustable settings.

### Additional Performance Features

- Speed droop on overload
- Preset speeds: software selectable
- Catch a spinning load
- PID control algorithm
- Critical speed avoidance
- Loss of control signal




# Advanced Microprocessor Features

### Simple Keypad Entry

Commands and parameter settings are made by entering information on the drive keypad. No separate terminals or modules are required for programming or troubleshooting. This eliminates potentiometer adjustments and operator "judgment" settings. The LCD display will show current, voltage, % speed, Hz, RPM, kW, kW/hr, DC bus volts, % rated torque and elapsed time.

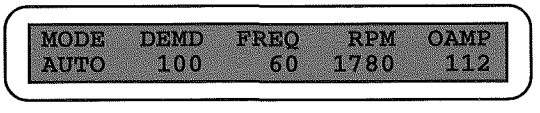
# Reports and Diagnostics

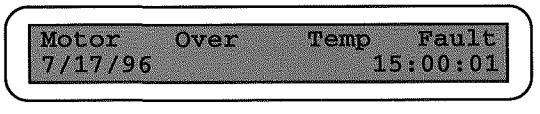
### Advanced Diagnostics

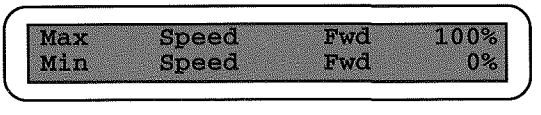
Diagnostic routines are built into the control circuits. Separate personal computers and auxiliary equipment are not required for diagnostic capabilities. Comprehensive monitoring of drive's control functions and a display of all system faults are shown on the keypad/display module. This provides easy and extensive troubleshooting with drive door closed. Historical record logs offer valuable operating information on events preceding a fault. Remote diagnostic capability is available via an optional modem connection.

### User Friendly Messages

Avoids codes and translating. All messages are in text.



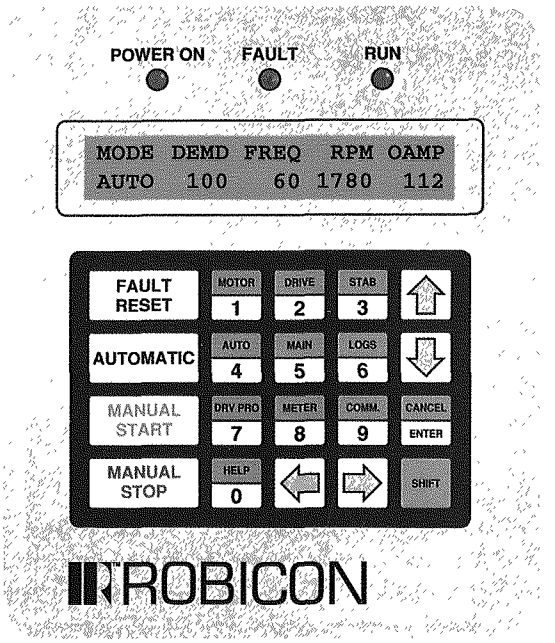



# User Friendly Operator Interface

## Keypad/Display Module

The Clean Power Series provides precise and repeatable parameter setting and adjustments. All values are entered via the keypad in engineering units.




## Digital Display

The keypad/display has a full alphanumeric character set. The display has two lines of 24 characters for messages regarding system status and parameter adjustments.

## On-Line Operation While Tuning

Parameter adjustments can be made while drive is operating.

## Security Code System

Fully programmable, multi-level, password-coded security system assures that entry will be achieved by authorized personnel only.

## Reports

Reports are stored in non-volatile memory and contain valuable operating information and diagnostic data.
The following reports can easily be retrieved via the serial port:

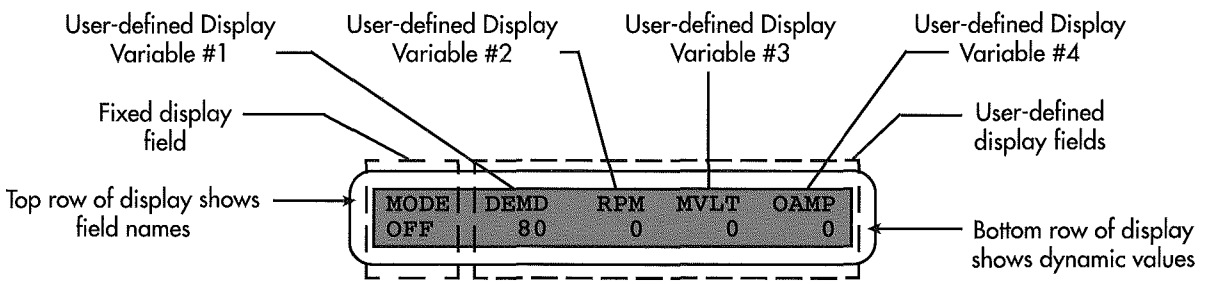
- Parameter log
- Fault log
- Historic log
- Diagnostic log

## Year 2000 Readiness

Robicon engineers have proactively addressed the impact of the Year 2000. The date on all Robicon drives is displayed in the format MM/DD/YY. Internally, the century digits are not maintained. No calculation or comparison is done on any Robicon system using the day or year. The largest increment of time that is significant to any Robicon drive is one hour, which is independent of the day, month and year. The time component is used for elapsed time functions. The year and day are used for logging functions only. For a complete disclosure of Robicon's Y2K readiness, visit www.robicon.com.

## Dynamic Programmable Meter Display

The meter display contains four user-defined display fields which can be programmed from the keypad. A pick list contains variables that can be displayed on the front panel LCD.




## Pick List Summary

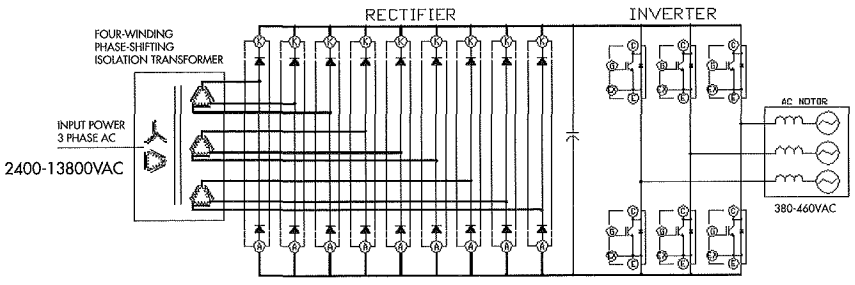
| Display Variable Name | Abbr |
|---|---|
| Motor Operating Frequency | FREQ |
| Motor Speed in RPM | RPM |
| Motor Speed in Percent | %SPD |
| Output Current | OAMP |
| Input Current | IAMP |
| Output Power in kW | kW |

| Display Variable Name | Abbr |
|---|---|
| Speed Reference | SREF |
| Motor Voltage | MVLT |
| Vdc | VDC |
| Line Voltage | VAV |

# Power and Control Options

## High Voltage Clean Power Input (2400–13800 VAC)

The benefits of clean power with high voltage input is an available option. With a four-winding isolation transformer in place of Robicon's patented standard auto-transformer, this drive can help users eliminate separate stepdown transformers by bringing medium voltage input directly into the facility or motor control room. The benefits of clean power input are also available in a medium voltage solution. By incorporating a four-winding transformer in place of Robicon's patented auto transformer, the customer saves space, reduces cost and increases overall efficiency.




## Constant Torque/Sensorless Vector Control

To realize the benefits of sensor vector control without the cost and maintenance of an encoder, Robicon provides sensorless vector control. This option raises the level of performance by allowing for general purpose constant torque drive system applications without encoder feedback. This option promotes fast response to main power line fluctuations and process side changes. This, combined with improved control with high starting torque or high torque at low speeds, can lead to higher overall motor and drive efficiency.

Hall effect sensors and sensorless vector software algorithms provide constant torque adjustable voltage and adjustable frequency control that is quiet, responsive, precise and simple. Drives with this option offer starting torque of 150%, automatic torque boost across the full range and a controlled speed range of 50:1. Dynamic braking is optional.

The sensorless vector control option is available in the full family of existing 454GT and Clean Power drives including all power ranges, voltage levels and line converter configurations.

## Power Options

- Input circuit breaker
- Contactor constant speed bypass
- VFD output contactor
- Output line reactor
- Constant torque
- Input disconnect
- Auto bypass
- TOL option
- Dynamic braking

# Communication and I/O Options

## Industry Standard Communication

The Clean Power Series has a microprocessor-based digital controller which offers more communications capability than any other drive of its kind.

The series can directly interface with many industry-standard communications systems and digital control schemes. Options include:

- Modbus-Plus™
- Allen-Bradley DH™, DH+™
- PROFIBUS DP™
- Siemens SIMATIC/TI505™
- Johnson Controls Metasys™
- Ethernet Modbus™
- Modicon Modbus™
- Reliance AutoMAX™, AutoMATE™
- DeviceNet™
- Diagnostic modem
- GE Genius™
- Other Programmable Logic Controller and serial interfaces available on request

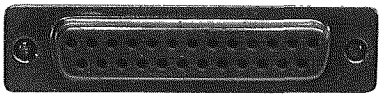
### Input/Output Capability

The Clean Power Series offers I/O capabilities in either digital or analog

- Two **isolated** analog inputs individually software configurable as 4-20 mA, 0-20 mA or 0-10 V
- Two programmable **isolated** analog outputs 4-20 mA such as speed, voltage and current
- Seven programmable, digital inputs, internally-derived 24 VDC non-isolated
- Three programmable form C relay digital outputs (dry contact)
- One programmable, 0-10 V non-isolated potentiometer input
- One system E-stop digital input, internally-derived 24 VDC non-isolated

### Standard Cable Connections

A standard DB25 cable enables easy connections with PCs and printers through our standard isolated serial port. These cables are available at most computer retailers.



# Service and Support

### Sales & Application Engineers

Robicon has been manufacturing variable frequency drives for more than 30 years. Our engineers have many years of application-specific experience in industrial, municipal and HVAC markets and are strategically located at headquarters and regional offices. Assistance is also available through our network of manufacturer's representatives. Our representatives are the first step in developing a drives system solution that saves time and money.

### Technical Support Center

Associates at our 24-hour help line (724-339-9501) provide immediate telephone assistance for customers needing help with troubleshooting, programming, installation or startup. Our contact management computer system enables our associates to assure continuity of your dialogue and provide fast and accurate solutions.

### Field Service Representatives

Field service representatives provide 24-hour emergency response around the world from 50 locations in addition to Robicon's factory. Our field service representatives are specifically trained to handle every phase of installation, startup, maintenance and troubleshooting of Robicon drives and to take full advantage of Robicon's extensive technical and operational resources.

### Commitment Management

Robicon's process-based order fulfillment places sales and project engineers on the same team to ensure all aspects of our commitment and diligent follow-through on your order.

### Factory Repair, Parts, Exchanges

Associates provide turnaround on repairs for most items in 24 hours. Exchanges are available to maximize uptime. Spare parts are held in strategic locations to provide same-day delivery and spare part kits are available to ensure critical applications.

### Warranty

Unlike many drives manufacturers, Robicon's warranty covers all on-site and in-house repairs, labor, materials and expenses.

### Technical Training

User Training Programs teach customers how to operate and maintain Robicon drives. These programs are conducted at customer sites and at Robicon's factory training center. Classes cover every drive configuration with basic and advanced courses for design, operation and maintenance personnel.

## Technical Specifications

| | |
|---|---|
| HP RANGE: | 50-800 HP |
| INPUT: | 380, 415, 460, 480 VAC ± 10% |
| INPUT POWER FACTOR: | .95 Displacement Power Factor at all operating speeds |
| VFD EFFICIENCY (FULL POWER): | 98% (basic drive) 96.5% (drive and transformer) |
| TOTAL HARMONIC CURRENT DISTORTION: | ≤ 5% at full load and speed (meets IEEE 519 1992 Table 10.3) |
| TOTAL HARMONIC VOLTAGE DISTORTION: | ≤ 3% Special Applications<br>≤ 5% General System<br>≤ 10% Dedicated System (meets IEEE 519 1992 Table 10.2) |
| FREQUENCY DRIFT: | ± 0.5% |
| VOLTAGE REGULATION: | ± 1% Rated Value, No Load to Full Load |
| SPEED REGULATION (MOTOR DEPENDENT): | 3% |
| CONTROL CIRCUITS: | 24 VDC |
| DESIGN: | Voltage Source, Pulse Width Modulated Space Vector |
| AMBIENT TEMPERATURE: | 0 - 40°C |
| ALTITUDE: | Maximum 3300 Feet Above MSL |
| CURRENT LIMIT: | 100% Continuous<br>50% - 120% Variable Torque<br>50% - 150% Constant Torque |
| ACCELERATION RATE: | 1 - 3200 Sec. Selectable |
| DECELERATION RATE: | 1 - 3200 Sec. Selectable |
| INPUT SPEED COMMAND: | Isolated 2 Wire, 4 - 20 mA Optional 3-15 PSI transducer<br>Isolated 2 Wire, 0 - 10 VDC<br>0 - 10 V potentiometer |
| ANALOG OUTPUTS: | Isolated 2 Wire, 4 - 20 mA, Programmable |
| OUTPUT FREQUENCY: | 0 - 400 Hz (consult factory for applications above 120 Hz) |
| SPEED RANGE: | 40:1 (motor dependent) |
| CURRENT CAPACITY: | 100% Continuous<br>120% for 1 minute variable torque<br>150% for 1 minute sensorless vector |
| STARTING TORQUE CAPACITY: | 150% for 1 minute (with sensorless vector option) |
| ELECTRONIC REVERSING: | Standard |
| JOGGING CAPABILITY: | Forward and Reverse |
| POWER LOSS RIDE-THROUGH: | 5 cycles |
| CONTROL POWER RIDE-THROUGH: | 2 seconds |
| INERTIA RIDE-THROUGH: | Load dependent |
| AUTOMATIC RESTART AFTER POWER LOSS: | Selectable |
| AUTOMATIC RESTART ON RE-SETTABLE TRIP: | Adjustable — 0 to 9 attempts |
| CRITICAL FREQUENCY REJECTION: | Adjustable bands — selectable - 3 |
| STALL PROTECTION: | Current limited — Acceleration, deceleration and run |
| RESTART INTO SPINNING MOTOR: | Synchronized |
| SLIP COMPENSATION: | Automatic |
| DYNAMIC BRAKING: | Optional |
| AUTOTUNING: | Standard |
| ENCLOSURE: | NEMA-1, NEMA-12 Ventilated |
| SERIAL PORT: | Isolated RS232/422/485 jumper selectable |
| AGENCY APPROVALS | UL, CUL (Most configurations) |

## Clean Power (480VAC) Overall Parameters

| Nominal HP 460Vac | VT / CT 100% | | Max Losses | | Req'd CFM | Drive w/Op Size (H x W x D) | Drive w/Op Weight (lbs.) | Drive w/Bypass (H x W x D) | Drive w/Bypass Weight (lbs.) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kw | BTU/hr | | | | | |
| 50 | 72 | 65 | 1.68 | 5,727 | 316 | 72 x 30 x 20 | 500 | 72 x 48 x 20 | 625 |
| 60 | 85 | 77 | 2.01 | 6,872 | 394 | 72 x 30 x 20 | 550 | 72 x 48 x 20 | 675 |
| 75 | 106 | 96 | 2.52 | 8,590 | 491 | 72 x 30 x 20 | 600 | 72 x 48 x 20 | 725 |
| 100 | 136 | 124 | 3.47 | 11,839 | 611 | 90 x 30 x 24 | 700 | 90 x 48 x 24 | 850 |
| 125 | 172 | 156 | 4.36 | 14,895 | 768 | 90 x 30 x 24 | 750 | 90 x 48 x 24 | 900 |
| 150 | 198 | 180 | 5.04 | 17,186 | 886 | 90 x 30 x 24 | 800 | 90 x 48 x 24 | 950 |
| 200 | 264 | 240 | 6.71 | 22,915 | 1,182 | 90 x 30 x 24 | 850 | 90 x 48 x 24 | 1000 |
| 250 | 330 | 300 | 8.39 | 28,644 | 1,477 | 90 x 30 x 28 | 900 | 90 x 48 x 28 | 1050 |
| 300 | 393 | 360 | 10.07 | 34,644 | 1,772 | 90 x 72 x 30 | 2800 | 90 x 96 x 30 | 3435 |
| 350 | 462 | 420 | 11.75 | 40,442 | 2,068 | 90 x 72 x 30 | 3000 | 90 x 96 x 30 | 3635 |
| 400 | 528 | 480 | 13.43 | 46,219 | 2,363 | 90 x 72 x 30 | 3000 | 90 x 96 x 30 | 3635 |
| 450 | 594 | 540 | 15.11 | 51,997 | 2,659 | 90 x 72 x 30 | 3100 | 90 x 96 x 30 | 3735 |
| 500 | 660 | 600 | 16.79 | 57,774 | 2,954 | 90 x 72 x 30 | 3200 | 90 x 96 x 30 | 3835 |
| 600 | 792 | 720 | 20.14 | 68,745 | 3,545 | 90 x 90 x 32 | 5200 | CF | CF |
| 700 | 924 | 840 | 23.5 | 80,202 | 4,136 | 90 x 90 x 32 | 5650 | CF | CF |
| 800 | 1,056 | 960 | 26.86 | 91,660 | 4,727 | 90 x 90 x 32 | 5750 | CF | CF |

CF: Consult Factory

## Clean Power (415VAC) Overall Parameters

| Nominal CT 415Vac Motor KW | Nominal VT 415Vac Motor KW | CT / VT 100% | | Max Losses | | Req'd CFM | Drive w/Op Size (H x W x D) | Drive w/Op Weight (lbs.) | Drive w/Bypass (H x W x D) | Drive w/Bypass Weight (lbs.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kw | BTU/hr | | | | | |
| 30.0 | 37.0 | 65 | 72 | 1.68 | 5,727 | 316 | 72 x 30 x 20 | 500 | 72 x 48 x 20 | 625 |
| 37.0 | 37.0 | 77 | 85 | 2.01 | 6,872 | 394 | 72 x 30 x 20 | 550 | 72 x 48 x 20 | 675 |
| 45.0 | 55.0 | 96 | 106 | 2.52 | 8,590 | 491 | 72 x 30 x 20 | 600 | 72 x 48 x 20 | 725 |
| 55.0 | 55.0 | 124 | 136 | 3.47 | 11,839 | 611 | 90 x 30 x 24 | 700 | 90 x 48 x 24 | 850 |
| 75.0 | 90.0 | 156 | 172 | 4.36 | 14,895 | 768 | 90 x 30 x 24 | 750 | 90 x 48 x 24 | 900 |
| 90.0 | 110.0 | 180 | 198 | 5.04 | 17,186 | 886 | 90 x 30 x 24 | 800 | 90 x 48 x 24 | 950 |
| 132.0 | 132.0 | 240 | 264 | 6.71 | 22,915 | 1,182 | 90 x 30 x 24 | 850 | 90 x 48 x 24 | 1000 |
| 160.0 | 160.0 | 300 | 330 | 8.39 | 28,644 | 1,477 | 90 x 30 x 28 | 900 | 90 x 48 x 28 | 1050 |
| 200.0 | 200.0 | 360 | 393 | 10.07 | 34,644 | 1,772 | 90 x 72 x 30 | 2800 | 90 x 96 x 30 | 3435 |
| 200.0 | 250.0 | 420 | 462 | 11.75 | 40,442 | 2,068 | 90 x 72 x 30 | 3000 | 90 x 96 x 30 | 3635 |
| 250.0 | 250.0 | 480 | 528 | 13.43 | 46,219 | 2,363 | 90 x 72 x 30 | 3000 | 90 x 96 x 30 | 3635 |
| 315.0 | 315.0 | 540 | 594 | 15.11 | 51,997 | 2,659 | 90 x 72 x 30 | 3100 | 90 x 96 x 30 | 3735 |
| 315.0 | 355.0 | 600 | 660 | 16.79 | 57,774 | 2,954 | 90 x 72 x 30 | 3200 | 90 x 96 x 30 | 3835 |
| 400.0 | 400.0 | 720 | 792 | 20.14 | 68,745 | 3,545 | 90 x 90 x 32 | 5200 | CF | CF |
| 450.0 | 500.0 | 840 | 924 | 23.5 | 80,202 | 4,136 | 90 x 90 x 32 | 5650 | CF | CF |
| 500.0 | 500.0 | 960 | 960 | 26.86 | 91,660 | 4,727 | 90 x 90 x 32 | 5750 | CF | CF |

CF: Consult Factory

## Clean Power (380VAC) Overall Parameters

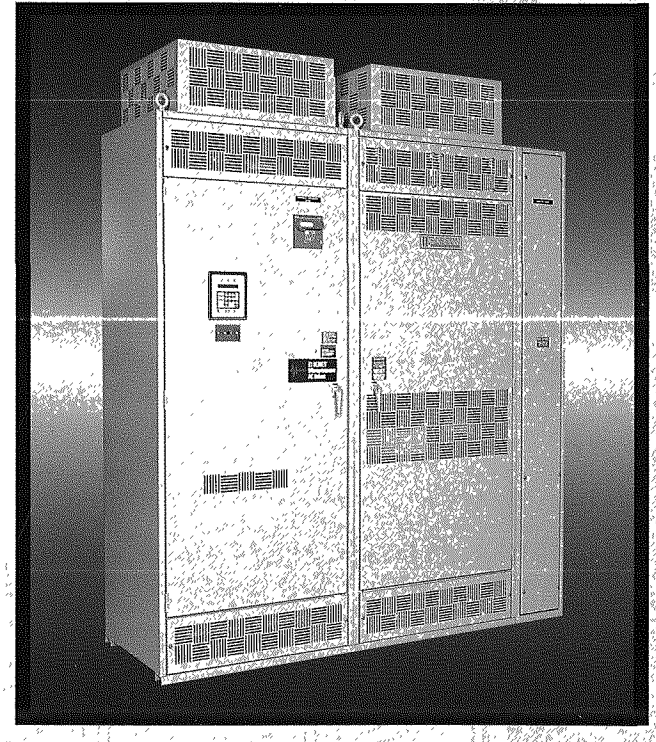
| Nominal CT 380Vac Motor KW | Nominal VT 380Vac Motor KW | CT / VT 100% | | Max Losses | | Req'd CFM | Drive w/Op Size (H x W x D) | Drive w/Op Weight (lbs.) | Drive w/Bypass (H x W x D) | Drive w/Bypass Weight (lbs.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kw | BTU/hr | | | | | |
| 30.0 | 30.0 | 65 | 72 | 1.68 | 5,727 | 316 | 72 x 30 x 20 | 500 | 72 x 48 x 20 | 625 |
| 37.0 | 37.0 | 77 | 85 | 2.01 | 6,872 | 394 | 72 x 30 x 20 | 550 | 72 x 48 x 20 | 675 |
| 45.0 | 45.0 | 96 | 106 | 2.52 | 8,590 | 491 | 72 x 30 x 20 | 600 | 72 x 48 x 20 | 725 |
| 55.0 | 55.0 | 124 | 136 | 3.47 | 11,839 | 611 | 90 x 30 x 24 | 700 | 90 x 48 x 24 | 850 |
| 75.0 | 75.0 | 156 | 172 | 4.36 | 14,895 | 768 | 90 x 30 x 24 | 750 | 90 x 48 x 24 | 900 |
| 90.0 | 90.0 | 180 | 198 | 5.04 | 17,186 | 886 | 90 x 30 x 24 | 800 | 90 x 48 x 24 | 950 |
| 110.0 | 132.0 | 240 | 264 | 6.71 | 22,915 | 1,182 | 90 x 30 x 24 | 850 | 90 x 48 x 24 | 1000 |
| 132.0 | 160.0 | 300 | 330 | 8.39 | 28,644 | 1,477 | 90 x 30 x 28 | 900 | 90 x 48 x 28 | 1050 |
| 160.0 | 200.0 | 360 | 393 | 10.07 | 34,644 | 1,772 | 90 x 72 x 30 | 2800 | 90 x 96 x 30 | 3435 |
| 200.0 | 200.0 | 420 | 462 | 11.75 | 40,442 | 2,068 | 90 x 72 x 30 | 3000 | 90 x 96 x 30 | 3635 |
| 200.0 | 250.0 | 480 | 528 | 13.43 | 46,219 | 2,363 | 90 x 72 x 30 | 3000 | 90 x 96 x 30 | 3635 |
| 250.0 | 250.0 | 540 | 594 | 15.11 | 51,997 | 2,659 | 90 x 72 x 30 | 3100 | 90 x 96 x 30 | 3735 |
| 250.0 | 315.0 | 600 | 660 | 16.79 | 57,774 | 2,954 | 90 x 72 x 30 | 3200 | 90 x 96 x 30 | 3835 |
| 355.0 | 400.0 | 720 | 792 | 20.14 | 68,745 | 3,545 | 90 x 90 x 32 | 5200 | CF | CF |
| 400.0 | 450.0 | 840 | 924 | 23.5 | 80,202 | 4,136 | 90 x 90 x 32 | 5650 | CF | CF |
| 450.0 | 450.0 | 960 | 960 | 26.86 | 91,660 | 4,727 | 90 x 90 x 32 | 5750 | CF | CF |

CF: Consult Factory

# ID-CSI 456

## AC Low Voltage Variable Frequency Drives

40-1500 HP  380 VAC-4160 VAC



The ID-CSI 456 Series is a rugged Variable Frequency Drive known for high performance and outstanding reliability.





IP7_024793

### Reliable Induction Motor Drive Design
This drive design provides energy and process efficient operation with full range speed control with smooth torque. Robicon has extensive drive experience and has supplied similar induction motor drive designs since 1975.

### Motor Compatibility
In many industrial applications, a VFD and the motor it drives are separated by tens or hundreds of feet, which requires long cables called motor leads, to connect the two together. Fast-changing PWM voltage pulses can interact with the distributed inductance and capacitance of the motor leads, which can result in an amplified peak voltage as high as 1600 volts at the motor terminals. This is known as the long-lead effect. It can stress and degrade the insulation around the stator windings of the motor and lead to premature motor failure. These problems typically occur at leads of 50 feet or greater. Robicon's ID® Series is a current regulated drive that is proven in high performance applications. Unlike typical PWM drives that generate high rise time, the ID® Series has less than 500V/μs dV/dT rise time and is capable of motor cable runs up to 1000 feet without motor insulation degradation.

### Microprocessor Control
Provides precise control with direct numerical entry of the variable needed to control the process. "Ease of operation" is the hallmark of this drive design. Control set-ups are easily and quickly tailored to meet the most demanding applications.

### Dual Performance
The ID® Series drives operate with any standard AC induction motor for variable torque or constant torque applications. The VECTOR CONTROL operating mode is built into the drive design. It can easily be implemented with the speed feedback device option for applications requiring low speed/high torque and 4-quadrant operation.

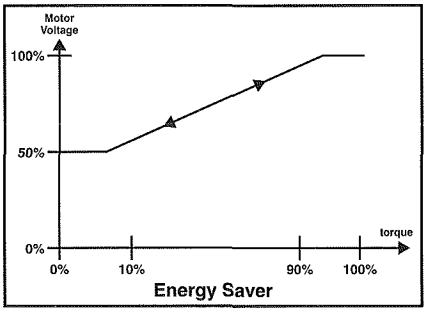
### Standard Rectifier Grade Thyristors
All thyristors are standard rectifier grade. Color coding, selecting or matching is not required.

### Single Thyristors
Single devices which eliminate parallel bridges are used for all drives.

### Short Circuit Protection
Design is inherently immune to any output short circuits, phase-to-phase or phase-to-ground.

### Open Circuit Protection
Output clamp protects against an open circuit on the VFD output. VFD can be operated open circuit for diagnostic purposes.

### Energy Saver
This feature sets the inverter output voltage as a function of the motor load, providing maximum motor efficiency over a wide range of load and duty cycles. This parameter specifies a minimum output motor voltage. A value of 50% represents a maximum energy savings potential, while a value of 100% represents no energy savings potential.




# Construction Features

### Soft Start
Motor draws no more than 100% current during start-up. This extends motor life, reduces equipment wear and prevents power line dips.

### Overtemperature
VFD is internally protected against overtemperature of power circuit and internal magnetics.

### High Speed Input Fuses
High speed semiconductor type fuses are used for thyristor protection.

### NEMA 1 Enclosure
Provides protection from falling dirt and accidental contact with enclosed parts.

### Air Cooled
Provides highest cooling system reliability. Eliminates complexity of hoses, pipes, pumps and associated liquid-cooled components.

### Modular Construction
Drive components are front-removable. Front access only is required.

### Isolated Control Circuits
Ensures operator safety.

# Protection Features

### Input Protection
- Undervoltage protection with selectable automatic restart
- Phase sequence insensitive
- Phase loss lockout
- Protected against sudden loss of input power
- Current limiting fuses

### Internal Protection
- Transient surge protection and R/C snubber networks
- Thyristor PIV ratings of 2.5 X line voltage
- Loss of cooling detection circuit with alarm
- Current limit
- Instantaneous and overvoltage trip

### Output Protection
- Overload trip, inverse time function
- Overvoltage trip
- Overspeed protection
- Protection against interruption of motor circuit
- VECTOR CONTROL MODE includes loss of speed feedback device protection
  Drive control prevents motor "run away" upon loss of feedback signal
- Output contactor not required for drive protection

### Short Circuit Protection
- Instantaneous overcurrent trip
- Circuitry designed to withstand short at output terminals without damage to input fuses or thyristors

### Customized Options
Robicon has the engineering expertise and superior product quality plus the true desire to design and manufacture a drive that is custom to each individual application.

# Control Features

### PWM Low Speed Operation
PWM (Pulse Width Modulated) Switching Mode provides smooth torque at low speeds.

### Vector Control Operation
Drive design inherently provides capability for high performance, 4-quadrant operation with the addition of speed feedback device option.

### Full Load Regeneration
The ID-CSI 456 drives are designed to provide full regeneration back to the utility power source for applications requiring breaking power.
- Quickly decelerated high inertia loads
- Controls overhauling loads that require reverse torque

### Active Adjustable Current Limit
Customer selectable via keypad to meet application requirement.

### Spinning Load Restart
The VFD can be smoothly started into a motor that's already turning in either direction (back-spinning or free-wheeling). Generally used with auto restart and large inertia loads.

### Automatic Restart
Provides restart after a drive trip or utility failure.

### Control Power Internally Derived
No auxiliary or external power is required.

### Speed Droop on Overload
Enables drive to ride through gradual overloads. Vector control option can be provided for transient overloads.

### Critical Speed Rejection
Permits selection of three critical speed rejection bands. VFD will ignore setpoint signals requiring operation within the rejection band.

### Direct or Reverse Acting Speed Profile
Provides individual user adjustable settings for Start, Stop, Entry, Exit, Slope, Minimum and Maximum Speed Points.

### Setpoint PID Regulation
Eliminates the need for an additional controller. Setpoint PID configuration is via the keypad/display module.

### Static Reversing
Changes drive thyristor firing sequence to operate motor in reverse direction.

### Optical Isolation
Provides signal isolation of 4-20 mA input speed command.

### 150% Overload Capability For One Minute
Short term overload for constant torque applications.

## Control Options

### Output Contactor
To isolate VFD from motor when desired.

### Vector Control Mode With Speed Feedback Device
Provides high starting torque; fast, closed loop regulator response; precise speed and torque control and fully regenerative operation.

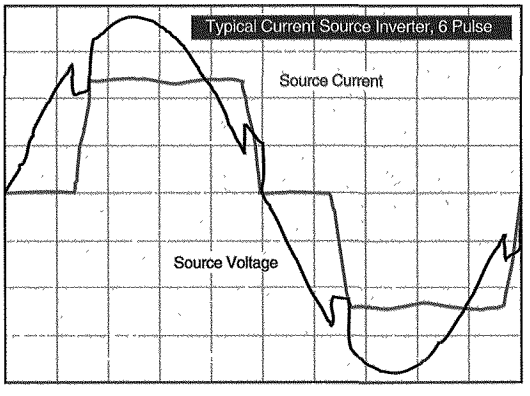
### Constant Voltage Control Transformer
Allows control to continue operating with a 30% undervoltage. Output speed may be reduced during period of undervoltage.

### Jog Speed
Allows user to momentarily operate the motor at an adjustable jog speed.

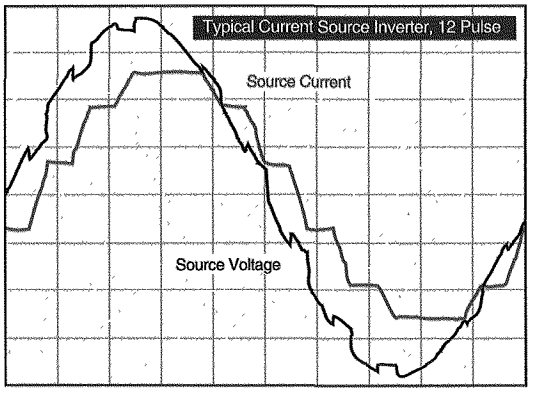
### Preset Speed
Allows user to operate the motor at up to eleven adjustable speeds which are selected by customer supplied contact closures.

## Harmonic Comparison

### 6-PULSE VS. 12-PULSE CURRENT WAVEFORMS




6-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 25% —*
*Total Harmonic Distortion (VOLTAGE) 10% —*




12-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 8.8% —*
*Total Harmonic Distortion (VOLTAGE) 3.9% —*

# Power and Control Options

## 12-Pulse Converter Input

The 12-pulse converter option can be supplied to reduce harmonic distortion when 6-pulse converters cannot meet recommended guidelines of IEEE 519 1992. Additional filtering can be provided if required.

## Harmonic Filters

To meet customer and utility specified distortion limits.

## Power Factor Correction Units

Designed to operate safely on customer power sources with harmonic producing equipment such as drives and rectifiers.

## Input Line Reactor

Reduces input harmonics and protects against voltage surges when input transformer is not provided. Line reactors minimize noise intrusion and act as input line noise suppressers.

## Circuit Breaker

Panel-mounted and door-interlocked for operator protection. Standard or high interrupting capacity available.

## Input Disconnect Switch

Panel-mounted and door-interlocked for operator protection.

## Electrical Contactor Constant Speed Bypass

Provides full voltage starter, VFD contactor, thermal overloads and VFD-OFF-LINE selector switch. Automatic transfer and input circuit breaker are also available options.

## Motor Overload Protection

Thermal overload blocks provided. (Required for motor protection when controlling two or more motors in parallel)

## Superclamp

Provides short term 150% overload for transient conditions.

# Microprocessor Standard Features

## Keypad/Display Module

Provides precise and repeatable parameter setting and adjustments. All values are entered via the keypad in decimal digits. The keypad entry process eliminates potentiometers and select resistors and is common to all Robicon drives.

## Digital Display

The keypad/display is conveniently located for easy one-touch operation and provides a programmable digital display of current, frequency, kW, RPM and % speed or voltage. kW-hour and Elapsed Time Meter displays are accessible through the keypad.

## Advanced Diagnostics

Diagnostic routines are built into the control circuits. Separate personal computers and auxiliary equipment are not required for comprehensive diagnostics. Provides continual, comprehensive monitoring of drive's control functions and a display of all system faults on the keypad/display module. Provides easy and extensive troubleshooting with drive door closed.

## User Friendly Messages

Avoids codes and translating. All fault messages and operating conditions are in text.

## On-Line Tuning While Operating

Tuning adjustments can be made while drive is operating.

## Logs

Record logs stored in non-volatile memory contain valuable operating information and diagnostic data. The following logging capabilities are provided:

- English Messages
- Extensive Diagnostics
- Fault Logs
- Parameter Logs
- On-Line Tuning
- RS232 Log Port
- Diagnostic Logs
- History Logs

# Communications and I/O Options

## Micro Programmable Logic Controller

Embedded application logic provides built-in I/O capability with modular I/O options. Provides 4 K words of memory for logic execution.

Modular I/O Options:

- Digital In — Supports 6 isolated inputs
- Digital Out — Supports 2 digital C outputs with 2 form "C" outputs each
- Analog In — Supports single and double ended voltage and 4-20 mA inputs
- Analog Out — Supports single and double ended voltage and 4-20 mA outputs
- Can support total of 16 digital and 16 analog modules

# Service and Support

## Sales & Application Engineers

Robicon has been manufacturing variable frequency drives for more than 30 years. Our engineers have many years of application-specific experience in industrial, municipal and HVAC markets and are strategically located at headquarters and regional offices. Assistance is also available through our network of manufacturer's representatives. Our representatives are the first step in developing a drives system solution that saves time and money.

## Technical Support Center

Associates at our 24-hour help line (724-339-9501) provide immediate telephone assistance for customers needing help with troubleshooting, programming, installation or startup. Our contact management computer system enables our associates to assure continuity of your dialogue and provide fast and accurate solutions.

## Field Service Representatives

Field service representatives provide 24-hour emergency response around the world from 50 locations in addition to Robicon's factory. Our field service representatives are specifically trained to handle every phase of installation, startup, maintenance and troubleshooting of Robicon drives and to take full advantage of Robicon's extensive technical and operational resources.

## Commitment Management

Robicon's process-based order fulfillment places sales and project engineers on the same team to ensure all aspects of our commitment and diligent follow-through on your order.

## Factory Repair, Parts, Exchanges

Associates provide turnaround on repairs for most items in 24 hours. Exchanges are available to maximize uptime. Spare parts are held in strategic locations to provide same-day delivery and spare part kits are available to ensure critical applications.

## Warranty

Unlike many drives manufacturers, Robicon's warranty covers all on-site and in-house repairs, labor, materials and expenses.

## Technical Training

User Training Programs teach customers how to operate and maintain Robicon drives. These programs are conducted at customer sites and at Robicon's factory training center. Classes cover every drive configuration with basic and advanced courses for design, operation and maintenance personnel.

## Technical Specifications

| | |
|---|---|
| HP RANGE: | 40-900 HP at 380/415 VAC<br>40-1250 HP at 460 VAC<br>40-1500 HP at 575 VAC<br>200 - 1500 HP at 2400 VAC<br>200 - 1500 HP at 4160 VAC |
| INPUT: | Nameplate voltage +10%, -5%, 3Ø at rated loads<br>50/60 Hz ± 5% |
| OUTPUT: | 380, 415, 460, 2400, 4160 VAC, 3Ø,<br>0-50/60 Hz |
| INPUT POWER: | Non Phase Sequence Sensitive |
| FREQUENCY DRIFT: | ± 0.5% from all factors |
| VOLTAGE REGULATION: | ± 1% rated value, no load to full load |
| SPEED REGULATION: | 3% of full load speed (motor dependent)<br>0.1% Steady State with Vector Control Option |
| SPEED RANGE: | 0-100% continuous (application dependent) |
| CONTROL CIRCUITS: | 120 VAC |
| AMBIENT TEMPERATURE: | 0-40°C (50° optional) |
| HUMIDITY: | 95% non-condensing |
| ALTITUDE: | Maximum 3300 feet above MSL (higher elevation ratings optional) |
| CURRENT LIMIT: | 0-100% adjustable |
| ACCELERATION RATE: | 0.5-3200 sec. adjustable (load dependent) |
| DECELERATION RATE: | 0.5-3200 sec. adjustable (load dependent) |
| OVERLOAD CAPABILITY: | 110% for one minute standard; 150% for one minute optional |
| INPUT SPEED COMMAND: | 4-20 mA isolated, 0-10 VDC non-isolated, 0-5 VDC non-isolated |
| MINIMUM SPEED: | 0-100% adjustable |
| MAXIMUM SPEED: | 0-100% adjustable |
| DUAL PERFORMANCE DESIGN: | STANDARD CONTROL and VECTOR CONTROL CAPABILITY |
| AGENCY APPROVALS | ETL (Most configurations) |

The Perfect Harmony solution utilizes proven transistor technology applied in a patented, innovative design to meet all of the power quality concerns.

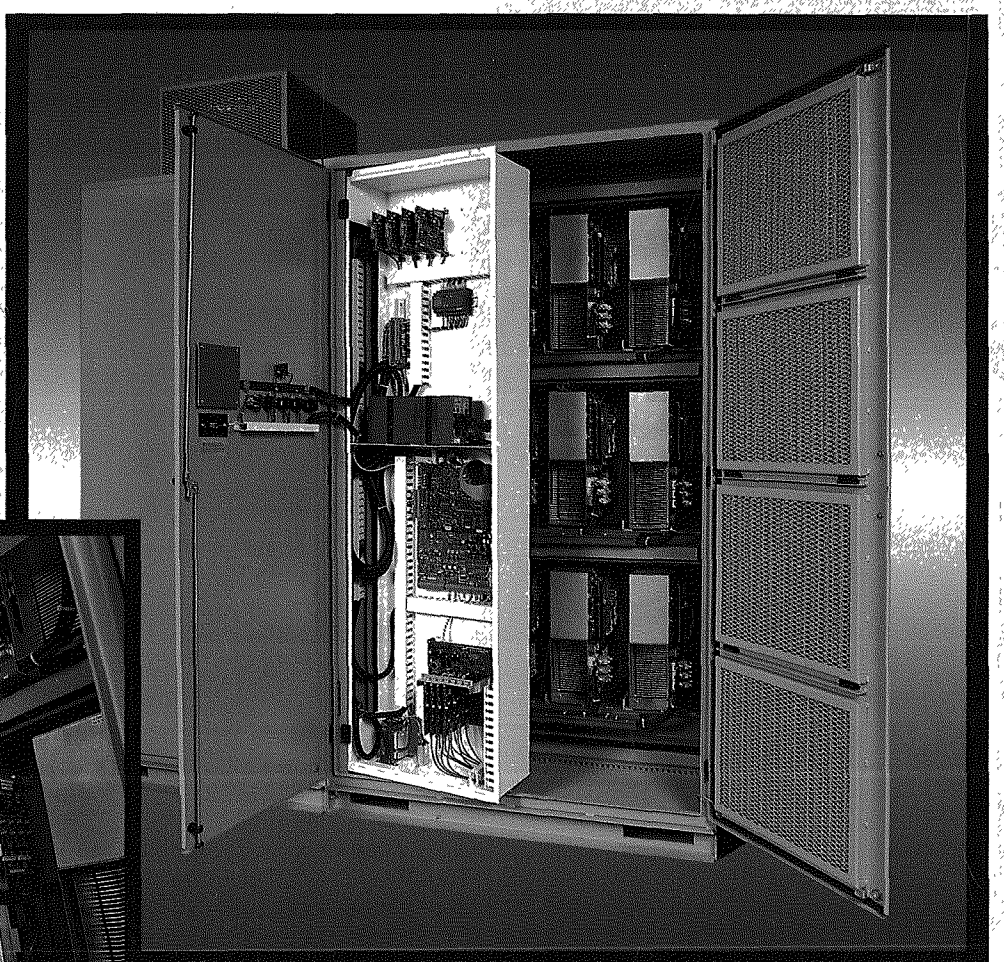
These high performance inverters offer superior power factor and harmonic control capabilities, modular design for easy maintenance, and Robicon's renowned user-friendly interface.

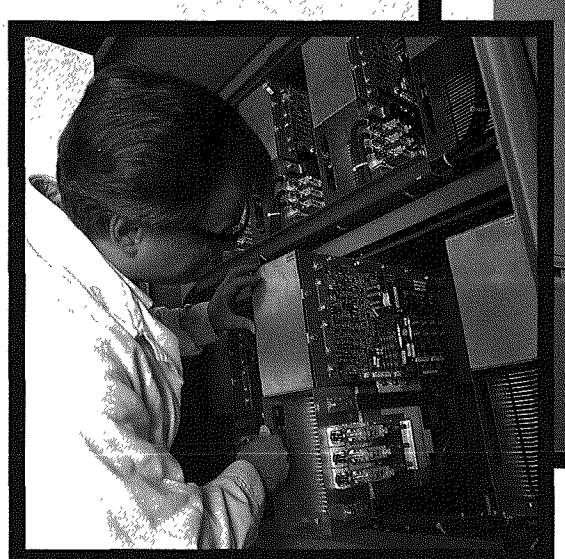
A true medium voltage solution, Perfect Harmony installations outnumber any other approach in major markets throughout the world.

# Perfect Harmony Series

## ID-PWM AC Medium Voltage Variable Frequency Drives

400 HP-30000 HP  2300 VAC-13800 VAC





The only AC VFD system solution designed to solve all power quality issues for induction, synchronous and wound rotor motors. It provides clean power input, high power factor, trip-free operation and near perfect sinusoidal output.





IP7_024801

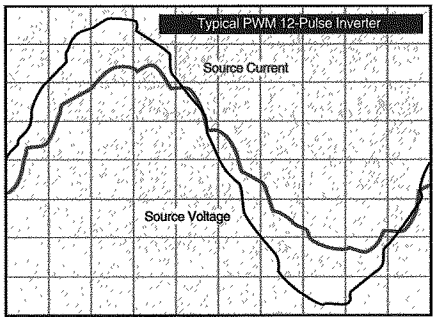
# Power Quality Input

## Clean Power Input

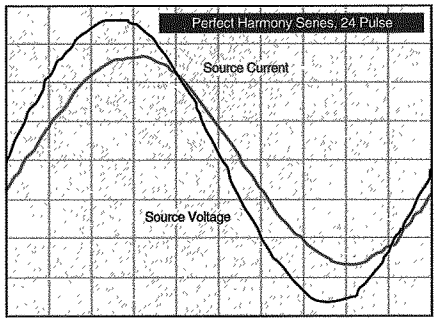
The Perfect Harmony series meets the most stringent IEEE 519 1992 requirements for voltage and current harmonic distortion, even if the source is only large enough to operate the load. Although a 12-pulse inverter is better than previous 6-pulse designs, it still cannot meet the most rigorous recommendations of IEEE 519 1992 for many power systems. This is why Robicon's minimum design is an 18-pulse input AC to DC converter.

- Protects other on-line equipment from harmonic disturbance (computers, telephones, lighting ballast)
- Prevents "cross-talk" with other variable speed drives
- Eliminates need for time consuming harmonic analysis
- Avoids costly harmonic filters and associated resonance problems

### Harmonic Comparison of Typical 1,000 HP 12-Pulse IGCT-PWM Inverter vs. Perfect Harmony Series Operating from 1,100 KVA, 5.75% Impedance Source




12-PULSE HARMONIC WAVEFORM
*Total Harmonic Distortion (CURRENT) 8.8% —*
*Total Harmonic Distortion (VOLTAGE) 5.9% —*



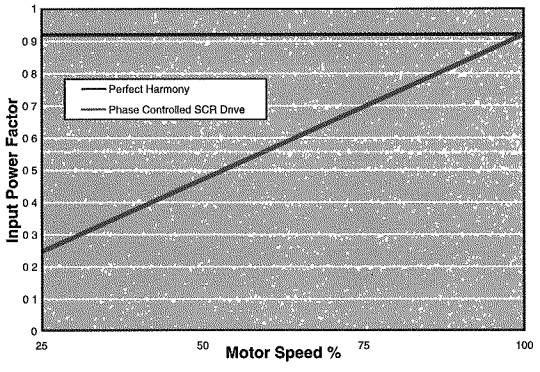

PERFECT HARMONY SERIES WAVEFORM
*Total Harmonic Distortion (CURRENT) 0.8% —*
*Total Harmonic Distortion (VOLTAGE) 1.2% —*

## High Power Factor

Exceeds .95 power factor at normal operating speeds without external power factor correction capacitors.

- Eliminates utility penalties for poor power factor
- Avoids overloading feeders, breakers and transformers with reactive power
- Improves voltage regulation
- Ideal for low synchronous speed induction motor applications. A high and stable power factor is maintained throughout entire speed range using standard induction motors

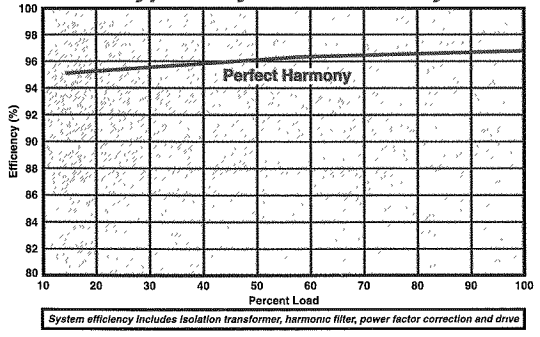
**HARMONY VS. CSI PWM (CENTRIFUGAL LOAD)**
**Measured Power Factor**




# High Efficiency

Perfect Harmony provides higher than 98% converter efficiency, 96%-97% total VFD system efficiency, including input transformer, harmonic filter, power factor correction capacitors and output filters. This far exceeds others when the transformer, power factor and harmonic filter losses are included in the total VFD system efficiency calculation.

*Typical System Efficiency*




*System efficiency includes isolation transformer, harmonic filter, power factor correction and drive*



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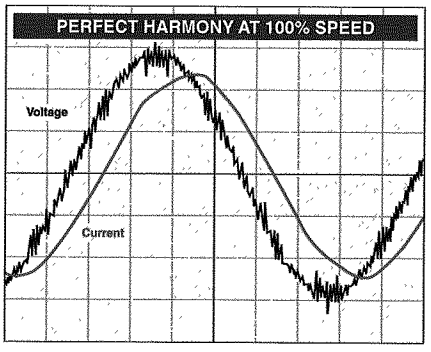
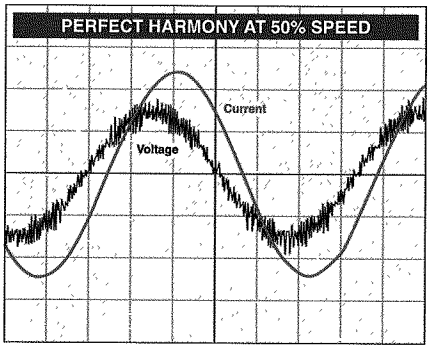
## Smart Electronics

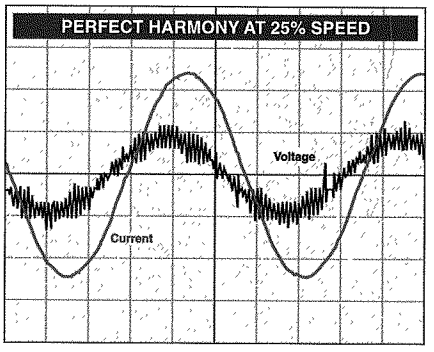
The Perfect Harmony utilizes smart electronics with IGBTs to deliver power quality waveforms without extra, large, costly, loss-adding filters. IGBTs are high volume, low-cost, robust devices with more than ten years of proven track record and availability from a number of suppliers. IGBTs utilize simple, low-power gate drivers compared to IGCTs, making them more reliable and easier to control. Unlike an IGCT, an IGBT will not be destoyed by any gate driver malfunction.

# Power Quality Output

The Perfect Harmony's unique multi-level PWM design inherently provides a sinusoidal output without the use of complex, external output filters. There is no degradation to waveform at lower speeds, unlike loss producing traditional designs which may be sinusoidal only at 60 Hz.




- Provides multi-level PWM output waveform with no appreciable audible motor noise
- Requires no motor derating — can be applied to new or existing 1.0 service factor motor and unity power factor synchronous motors. **Can be applied with motors from any manufacturer without special design considerations**
- Eliminates harmful VFD-induced current harmonics which cause motor heating
- Inherently protects motor against common mode voltage and dV/dT stress, regardless of cable length
- Eliminates VFD-induced torque pulsations, even at low speeds, so there is minimal stress to mechanical equipment
- Allows standard motor and cable insulation.
- Special insulation for DV/DT for common mode voltage is not required

## Output Torque Spectrum

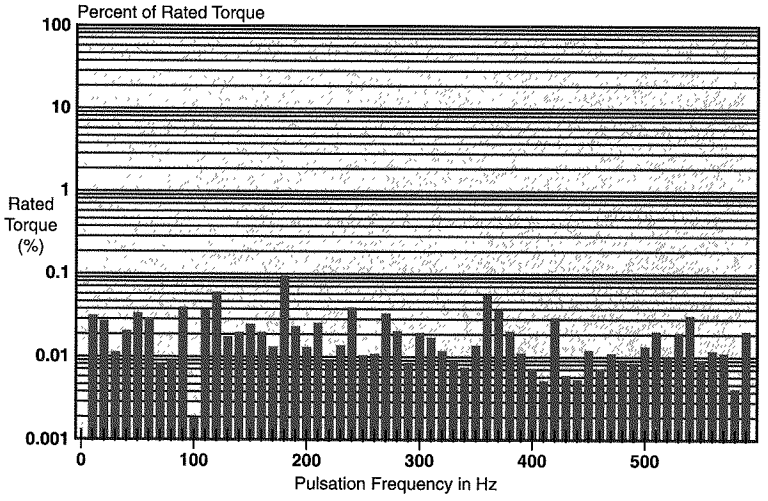
Low output motor torque harmonics reduce torsional stress on equipment (motor coupling, gearbox, driven load, etc.).

## Soft Start Protection

Prevents power-line dips due to motor inrush currents and extends motor and equipment life.

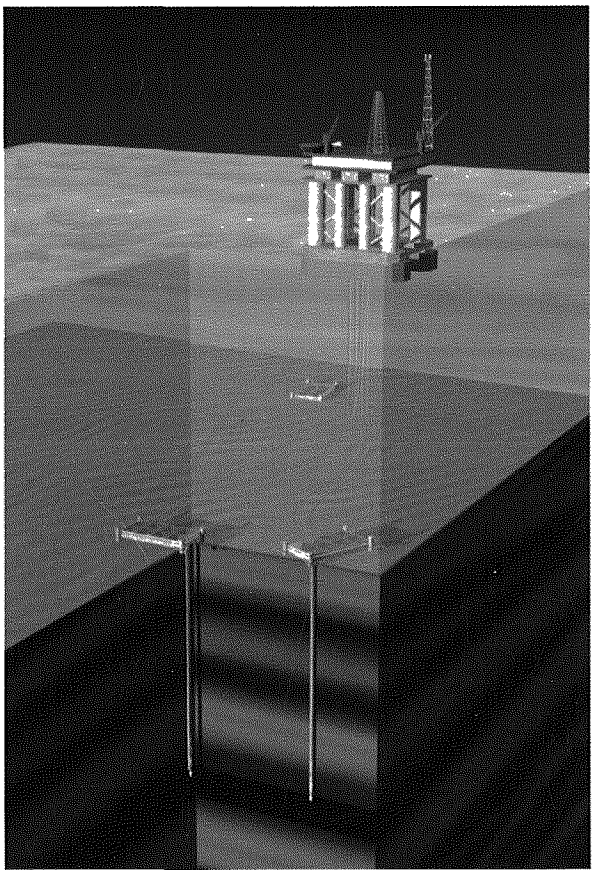
### Torque Pulsations

**Robicon "Perfect Harmony" Series @ 30 Hertz, Full Load**




**Torque Pulsations at 30 Hertz, Full Load 900 HP, Four-Pole Motor on Robicon Perfect Harmony Variable Frequency Drive**

# Motor Cable Lengths



The Perfect Harmony drive system owns world records in terms of electrical transmission distance for electrical submersible pumps. Perfect Harmony systems are operating in three oil production fields globally and have been field tested at 5km, 10km, 15km and 20km cable lengths. Perfect Harmony needs no site-specific dedicated filters to control harmonics so there is no retuning for power system changes. Also, users can change cable lengths and pump sizes within the horsepower range without redesigning an output filter. Current harmonics are minimized. And with virtually no output harmonics, there are no problems with motor, cables, or torque pulsations. Even at long cable lengths, there are no problems with cable over-voltage. Excerpts from published technical papers follow:

"Theoretical analysis, supported by field trials, has demonstrated the very low harmonic content of this drive/cable/motor combination. The field trials, using redundant downhole cable, have been carried out at 5, 10, 15 and 20 km cable length by Reda Pumps in Inverurie."
*(Gannet E: The World's Longest Subsea ESP, SPE 38534, 1998 Offshore Europe Conference)*

"A final test was held in order to determine if the motor iron would saturate and overheat for an over-voltage of 10% and to determine if the motor would overheat or stall for an under-voltage of 5% with full load shaft. Conclusion of the tests was that motor temperature will not be a concern for terminal voltage within the tested range."
*(Gannet E Subsea ESP: The Application of Technology in Practice, SPE 50596, European Petroleum Conference 10/98)*

"Low harmonic VFDs currently installed and operating at Canõ Limon have increased potential oil production an average of 50,000 barrels per year per well. The energy consumed per barrel lifted is lower. Annual energy bill is lowered around US $10,000 per year per well."
*(Medium Voltage Variable Frequency Drives with Low Harmonic Distortion, 1998 Electric Submersible Pump Workshop)*

# Reliability and Performance

## MTBF

With more than 700 units sold and operating worldwide, Perfect Harmony has a "field proven" mean-time-before-failure of 51,000 hours, based on actual operating experience. When equipped with complete and redundancy options, the MTBF is approximately 100,000 hours.

## Parts Count Reduction

The evolution of the Perfect Harmony design has led to a 20% parts reduction while maintaining its industry-leading power quality characteristics without output filters, common mode reactors, and other items or power devices needed for protection.

## Testing

All Robicon drives with corresponding isolation transformers are shipped full-load tested to the customer site. With an integral isolation transformer, Perfect Harmony is a "plug-n-play" drive system. A complete factory load test assures customers that their VFD with transformer isn't being tested for the first time at their site.

## Reliability

Proven, transistorized PWM design assures maximum reliability.

## Fiber Optic Control Circuitry

Noise-free two-way optical link employs precise, high-speed digital communication. And it ensures high voltage isolation between low voltage control and high voltage power section.

### Air or Liquid Cooling Systems
Available with either forced air cooling or self-contained, closed loop liquid cooling. (Liquid-to-Liquid or Liquid-to-Air heat exchangers available.) Redundant pumps are standard on liquid-cooled units. Redundant blower available for air-cooled units.

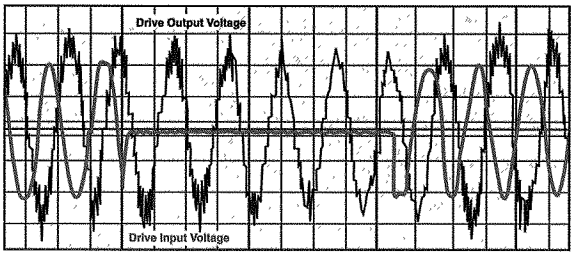
### Multi-Motor Operation
Drive can easily accommodate multiple motor applications.

### Integral Isolation Transformer
The Perfect Harmony solution utilizes an integral isolation transformer, which is factory mounted and pre-wired to the VFD. This eliminates the cost of external customer remote mounting of the transformer with the field wiring and cost of conduit or cable trays. In order to achieve maximum reliability of each Perfect Harmony system all transformers are shipped from our transformer suppliers to Robicon's facility for complete full load string testing of the transformer with each VFD. This insures that any problems or defects are found on Robicon's factory floor and not at the customer's site at time of startup. The Perfect Harmony transformer utilizes the best available insulation system rated for 220°C. Most VFD suppliers utilize oil-filled transformers which require expensive environmental safeguards or less expensive dry-type transformers, which operate at 150°C rise that reduce system efficiency and transformer life. However, Robicon operates the Perfect Harmony dry type air-cooled transformers at 115°C rise (just 80°C rise on larger liquid-cooled units) yielding higher efficiencies and longer equipment life.

### Sensorless Vector Control
This option raises the level of performance for constant torque general purpose motoring drive applications. Vector control provides improved control for high starting torque and high-torque/low-speed. Hall effect sensors and vector control software algorithms provide constant torque adjustable voltage and adjustable frequency control that is quiet, responsive, precise and simple. Drives with this option offer full rated torque across the full range and a controlled speed range of 50:1 or better. The vector control option is available in the full family of Perfect Harmony drives including all power ranges, voltage levels and line converter configurations.

## Maximized Up-Time
The Perfect Harmony Series will keep your system up and running through most common failures. That means no loss of production and an improved bottom line.

**Perfect Harmony**
**5 Cycle Power Loss Ride-Through**
**@ 100% Load**




### Trip-Free Operation
Can ride though a 30% voltage dip, or loss of power for 5 cycles.

### Thermal Ride-Through
Drive will stay on-line at reduced capacity instead of tripping on excessive ambient temperature.

### Spinning Load Restart
In the event of more serious interruptions, the drive can be restarted into a motor that is still spinning and resume operation.

### Modular Construction
Power cells are identical to one another and are mounted on a rack-out assembly for easy removal and on-site repair. Modular construction offers a mean time to repair of approximately 15 minutes. Cells are easily replaced by disconnecting 5 leads and 1 fiber optic cable.

### ProToPS™
Process Tolerant Protection Strategy is a standard implementation of the VFD SOP (System Operating Program) designed to provide the operator with indication of a change in the state of the VFD. These annunciations identify changes that can impact the ability of the VFD to meet process demands or provide advanced indication of a pending VFD trip. ProToPS™ allows the process operator to make process corrections to the VFD in use or adjust the process to address a pending VFD trip.

# Redundancy Options

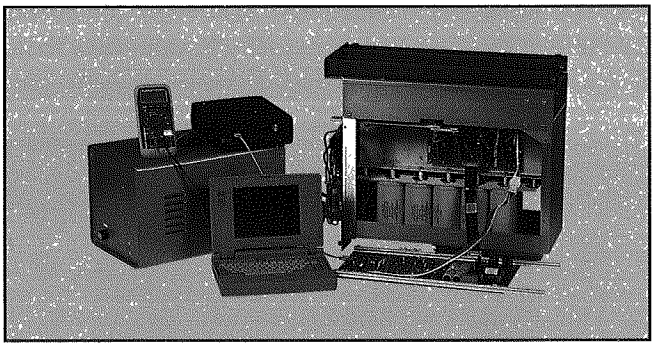
## Cell Bypass Option

This feature improves VFD availability by shunting a faulted power cell and resuming operation at reduced capacity with remaining cells. This allows the process to continue and maintenance to be postponed until a convenient time.

```
CELL A-4 BYPASSED
```

## Power Cell Diagnostics and Repair

Unlike high voltage SCRs, GTOs, IGCTs and SGCTs, Perfect Harmony power cells can be repaired in the event of failure. There are no special or matched components. Harmony cells use standard low voltage components and give users the safety and convenience of low voltage, stand-alone diagnostics and troubleshooting. Shown is an optional power cell bench tester kit.



# Reports and Diagnostics

The Perfect Harmony Series drive offers user-programmable diagnostic tools. Advanced multi-channel fiber optic communication diagnostics provide for the most comprehensive evaluation available.

## On-Line Tuning and Diagnostics

System can be reviewed and adjustments made while drive is operating. Allows operator to adjust tuning parameters while drive is running.

```
RAMP SETUP
→ FWD ACCEL 2.0 SEC
```

## Power Cell Check

Upon initialization, the drive verifies the integrity of each power cell, even to the power transistor level. Thereafter, the drive monitors the status of each power cell and all of the associated components.

```
INITIAL STATUS CHECK
ALL POWER CELLS OK
```

## Reports

Reports are stored in nonvolatile memory and contain valuable operating information and diagnostic data. The following reports can easily be retrieved via printer or CRT:

- diagnostic log
- historic log
- cell fault log
- parameter log
- fault log
- cell status

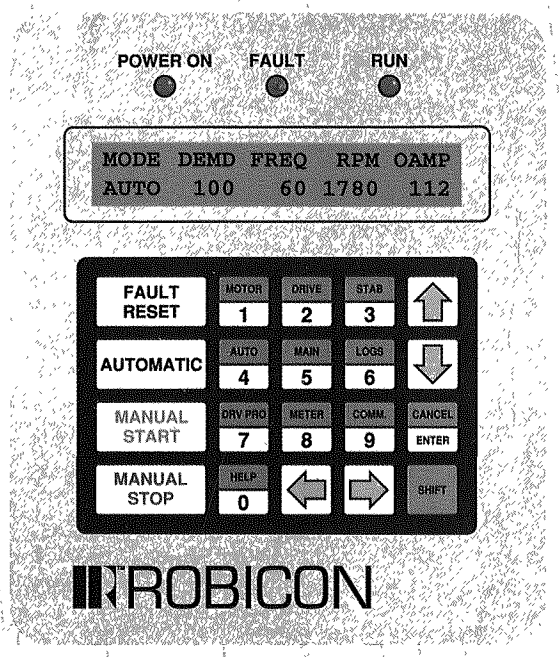
**********
PARAMETER SETTINGS
**********

| Parameter | | Min Limit | Max Limit | Level |
|---|---|---|---|---|
| Motor Freq | 60 Hz | 50 | 60 | 1 |
| No of Poles | 4 | 2 | 12 | 1 |
| FL Speed | 1800 RPM | 475 | 3780 | 1 |
| Motor Volts | 460 V | 300 | 750 | 1 |
| Motor FLC | 500 A | 0 | 1000 | 1 |
| Motor kWs | 209 kWs | 15 | 1000 | 1 |
| I min | 109 A | 0 | 500 | 1 |
| I max | 500 A | 0 | 1000 | 1 |
| I drive | 500 A | 0 | 1000 | 1 |
| Acn. time | 15.0 sec | 2.0 | 300.0 | 1 |
| Dcn. time | 20.0 sec | 2.0 | 300.0 | 1 |
| I init | 40 A | 0 | 1000 | 1 |
| Flux Pause | 3.0 sec | 1.0 | 30.0 | 1 |
| V Min | 0 V | 0 | 50 | 1 |

# Microprocessor Standard Features

## Keypad/Display Module

Provides precise and repeatable parameter settings and adjustments. All values are entered via the keypad in decimal digits. The keypad entry process eliminates potentiometers and select resistors, and is common to all Robicon drives.




## Digital Display

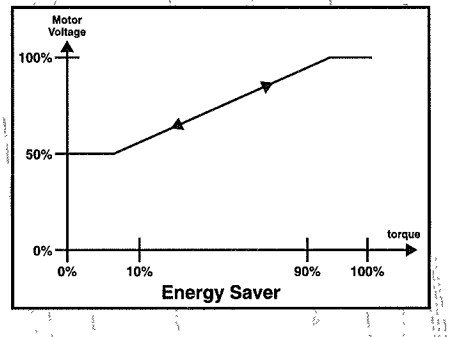
The keypad/display is conveniently located for easy one-touch operation and provides a programmable digital display of amps, frequency, kW, rpm, % speed or voltage. kW-Hour and Elapsed Time Meter displays are accessible through the keypad.

## Advanced Diagnostics

Diagnostic routines are built into the control circuits. Separate personal computers and auxiliary equipment are not required for diagnostics. Provides continual, comprehensive monitoring of drive's control functions and a display of all system faults on the keypad/display module. Provides easy and extensive troubleshooting with drive door closed.

## Energy Saver

This feature sets the inverter output voltage as a function of the motor load, providing maximum motor efficiency over a wide range of load and duty cycles. This parameter specifies a minimum output motor voltage. A value of 50% represents a maximum energy savings potential, while a value of 100% represents no energy savings potential.




## User Friendly Messages

Avoids codes and translating. All fault messages and operating conditions are in text.

# Pre-Engineered Options

Robicon has developed standard "pre-engineered" options in response to feedback from the Perfect Harmony user base and field service data. Advantages include standardization, proven design, quick delivery and cost savings. Some options are mutually exclusive, contingent upon other options and may affect dimensions.

## Power Options

- Fused disconnect switch
- Power cell bypass
- Constant speed/full voltage bypass
- Constant speed/reduced voltage bypass
- Keyed interlocks
- High voltage input to 34.5 kV
- 50 Hz or 60 Hz input
- Copper-wound main transformer
- Synchronous transfer (consult factory)
- Input surge arrestors

## Control Options

- Redundant control power feed
- 120 V UPS for control power
- Control power transformer
- Modular I/O expansion
- High performance vector control
- Serial communications

## Metering Options

- Power Meter
- 3Ø input ammeter and voltmeter
- Multilin 269+™ motor relays
- Multilin SR469™ motor relays
- 8 channel motor RTD monitor
- Multilin Power Quality Meter (PQM™)

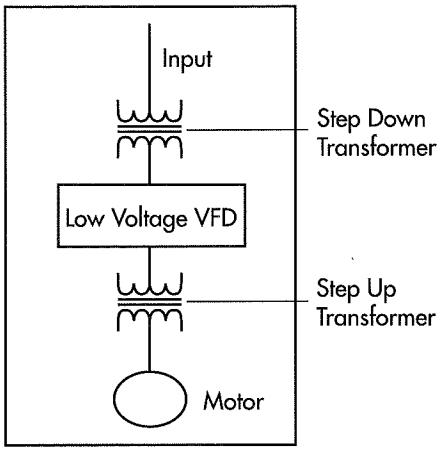
## Custom Options

- Control house
- Redundant ventilation blower
- Output contactor
- Report printer
- Touch screen display

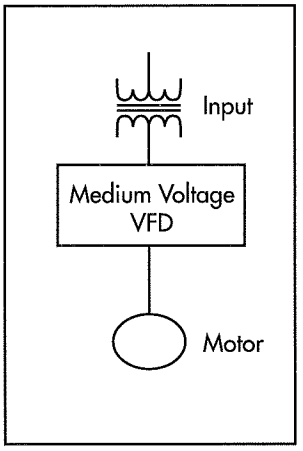
# Robicon Perfect Harmony

Compared to the Perfect Harmony approach, a low voltage solution with step up and step down transformers is less efficient, provides lower starting torque, has higher installation cost and generates more heat load to the motor control room.

TYPICAL LOW VOLTAGE CONFIGURATION




PERFECT HARMONY

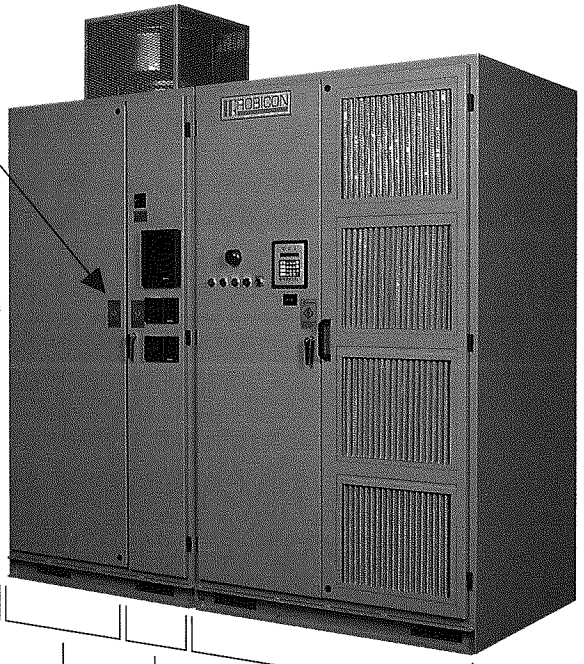



3Ø connection to motor

3Ø connection to utility

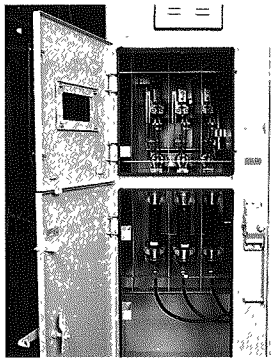
## Perfect Harmony

The closest thing to plug-n-play. Simple 3Ø power in/out connections with no site interconnection wiring.

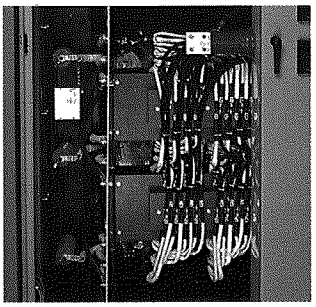



One integral solution (Offers efficiency improvements of 3-4%, more starting torque, less heat load to motor control room, lower install cost)

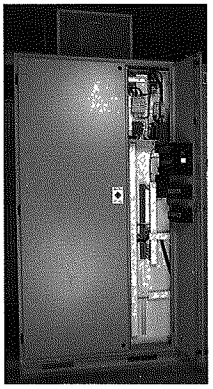
Medium Voltage Input and Output Section (Allows both top and bottom entry/exit)



Input Load Break Disconnect Switch (Optional)

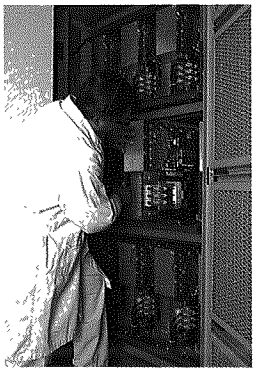


Input Isolation Transformer (Factory pre-wired for easy, low cost field installation)



Customer Control Section (Allows both top and bottom entry/exit)

Power Cell Section



Rack Out Design (Less mean time to repair)



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# Communication and I/O Capabilities

## Input/Output Options

The Perfect Harmony Series offers I/O capabilities in both digital and analog.

- Two isolated analog inputs individually software configurable as either 4-20 mA, 0-20 mA or 0-10 V.
- Up to three programmable isolated analog outputs 4-20 mA such as speed, voltage and current.
- Seven programmable, digital inputs, 120 VAC isolated.
- One system E-stop digital input, 120 VAC isolated.
- Three programmable from C relay digital outputs (dry contact).
- One programmable, 0-10 V non-isolated potentiometer input.

## Industry Standard Communications

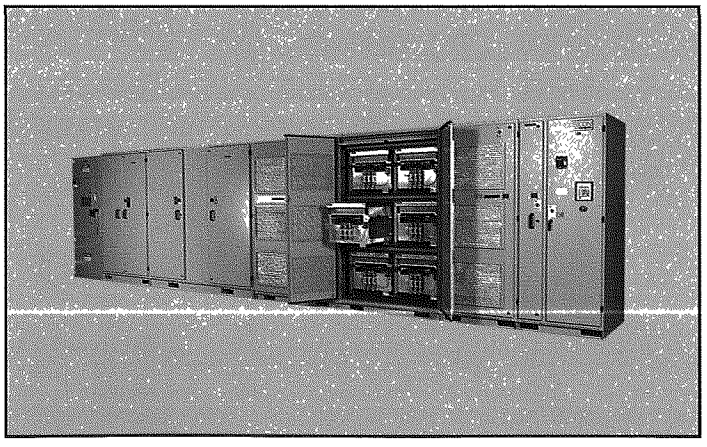
The Perfect Harmony has a microprocessor-based digital controller which offers more communication capability than any other drive of its kind.

The Perfect Harmony Series can directly interface with industry-standard communications systems, energy management systems and other digital control schemes including the following networks:

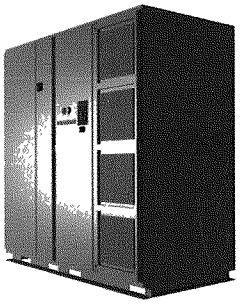
- Modicon Modbus™ or Modbus-Plus™
- Allen Bradley DH™, DH+™
- DeviceNet™
- Reliance AutoMAX™, AutoMATE™
- Siemens SIMATIC/TI505™
- GE GENIUS I-O™
- PROFIBUS DP™
- GE Genius™
- Ethernet™
- Other Programmable Logic Controller and serial interfaces available on request

## Standard Cable Connections

A standard DB25 cable enables connections with PCs and printers. These cables are available at most computer retailers.



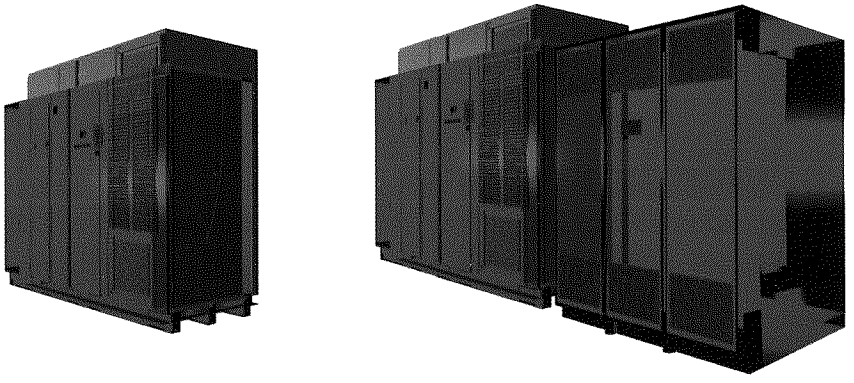
# Perfect Harmony Footprint Comparison



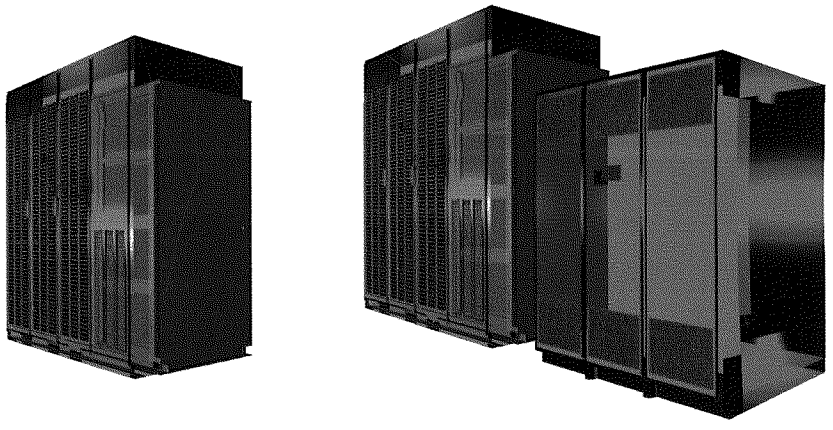
The Perfect Harmony is an integrated drive system. It includes the isolation transformer and arrives at the customer site fully integrated, wired and full-load tested. Some suppliers only discuss inverter dimensions and usually don't provide details of integration and the transformer. With available space in motor control rooms at a premium, users must consider the complete drive system lineup in their evaluations.

# Drive vs. Drives Systems

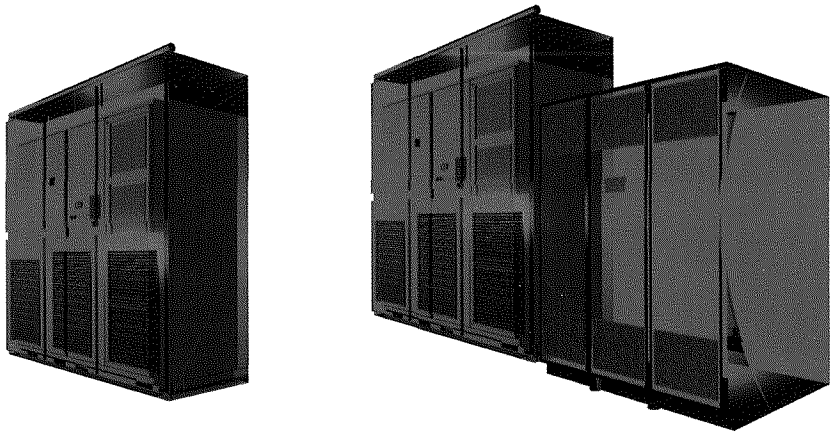
The illustrations below compare a 1,000 Hp, 4160 VAC Perfect Harmony to competing systems with and without required isolation transformers. All three alternative drives require integration of the drive and transformer at the customer site, including wiring and testing.



IGCT Neutral Point Clamp Inverter and complete drive system vs. Perfect Harmony.



3-Level, High Voltage, Voltage Source PWM Inverter and drive system vs. Perfect Harmony.



Current Source PWM inverter and drive system vs. Perfect Harmony.

Note: Inverter dimensions come from published sales materials. Transformer dimensions are an approximate based on the dimensions at one particular supplier.

# Service and Support

## Sales & Application Engineers

Robicon has been manufacturing variable frequency drives for more than 30 years. Our engineers have many years of application-specific experience in industrial, municipal and HVAC markets and are strategically located at headquarters and regional offices. Assistance is also available through our network of manufacturer's representatives. Our representatives are the first step in developing a drives system solution that saves time and money.

## Technical Support Center

Associates at our 24-hour help line (724-339-9501) provide immediate telephone assistance for customers needing help with troubleshooting, programming, installation or startup. Our contact management computer system enables our associates to assure continuity of your dialogue and provide fast and accurate solutions.

## Field Service Representatives

Field service representatives provide 24-hour emergency response around the world from 50 locations in addition to Robicon's factory. Our field service representatives are specifically trained to handle every phase of installation, startup, maintenance and troubleshooting of Robicon drives and to take full advantage of Robicon's extensive technical and operational resources.

## Commitment Management

Robicon's process-based order fulfillment places sales and project engineers on the same team to ensure all aspects of our commitment and diligent follow-through on your order.

## Factory Repair, Parts, Exchanges

Associates provide turnaround on repairs for most items in 24 hours. Exchanges are available to maximize uptime. Spare parts are held in strategic locations to provide same-day delivery and spare part kits are available to ensure critical applications.

## Warranty

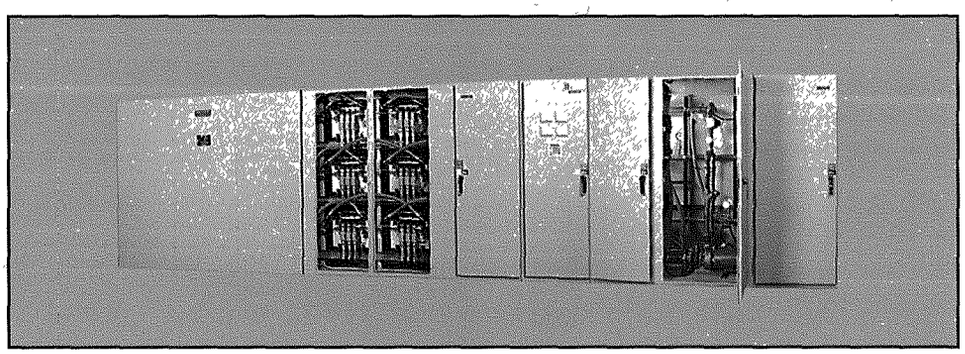
Unlike many drives manufacturers, Robicon's warranty covers all on-site and in-house repairs, labor, materials and expenses.

## Technical Training

User Training Programs teach customers how to operate and maintain Robicon drives. These programs are conducted at customer sites and at Robicon's factory training center. Classes cover every drive configuration with basic and advanced courses for design, operation and maintenance personnel.

## Technical Specifications

| | |
|---|---|
| HP RANGE: | 400 HP - 30000 HP<br>2300 VAC - 13800 VAC |
| DESIGN: | Multi-Level PWM |
| INPUT: | +10%/-5% at full power, +10%/-30% at reduced power |
| OUTPUT: | SINUSOIDAL; 0-7200 VAC |
| INPUT POWER FACTOR: . | .95 from 20% to 100% load |
| INPUT POWER: | Non Phase Sequence Sensitive |
| FREQUENCY DRIFT: | ± 0.5% from all factors |
| SPEED RANGE: | 0-100% continuous (application dependent) |
| CURRENT RATING: | 100% continuous; 150% for 1 minute (optional) |
| ACCELERATION RATE: | 0.1 - 3200 sec. adjustable (load dependent) |
| DECELERATION RATE: | 0.1 - 3200 sec. adjustable (load dependent) |
| OUTPUT FREQUENCY: | 0 - 50/60 Hz; customer selectable up to 250 Hz |
| ENCLOSURE: | NEMA-1 Ventilated air-cooled, NEMA-12 liquid cooled, IP21, IP52 |
| AMBIENT TEMPERATURE: | 0 - 40°C; higher available |
| HUMIDITY: | 95% non-condensing |
| ALTITUDE: | Maximum 3300 feet above MSL; higher available |
| MOTOR TYPES: | Induction, Synchronous, Wound Rotor |
| APPLICATIONS: | All constant and variable torque |
| QUALITY ASSURANCE: | ISO 9001 Registered |





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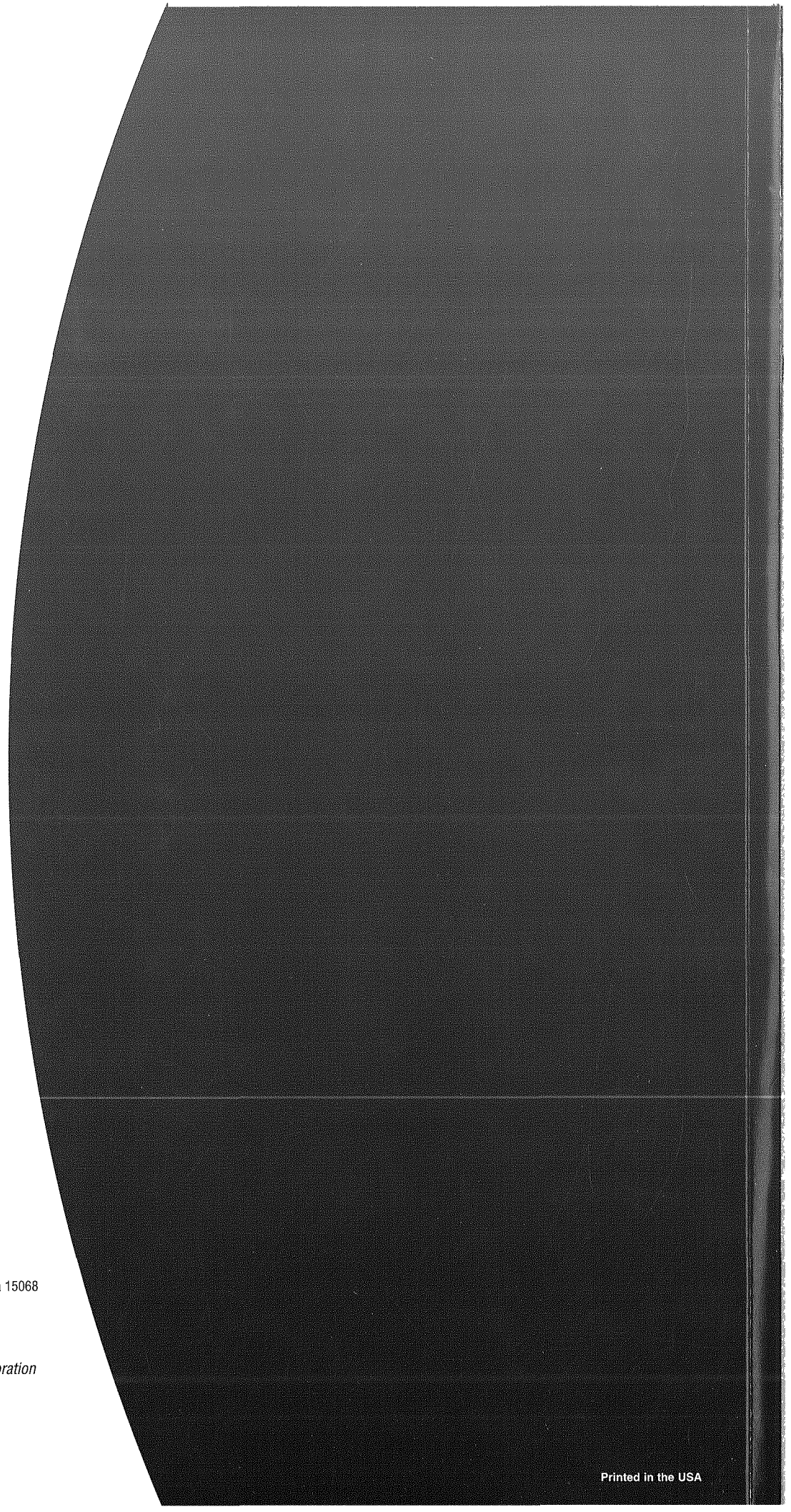

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